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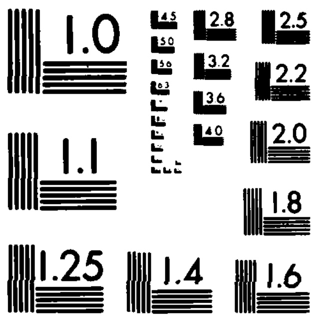

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Radar bridge patterns extraction and recognition

Pi-Fuay Chen
Neil D. Fox

April 1983

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A technique is described for detecting and recognizing various bridge patterns with different orientation angles from a set of radar imagery. The algorithm combines Hough transform, Sobel edge operator, image thresholding methods, and decision logics and was implemented as a software for an experimental hardware system consisting of a 32-element by 32-element solid-state array, a minicomputer, and a computer-controlled translational stage. The resolution of bridge orientation angle detection was determined to be approximately 22.5 degrees for the current system setup. This resolution can be improved by enlarging the input measurement array size.

PREFACE

This study was conducted under DA Project 4A161102B52C, Task B, Work Unit 012, "Electronic Image Analysis for Feature Extraction."

The study was done under the supervision of Dr. F. Rohde, Team Leader, Center for Physical Sciences; and Mr. M. Crowell, Jr., Director, Research Institute.

COL Edward K. Wintz, CE, was Commander and Director and Mr. Robert P. Macchia was Technical Director of the Engineer Topographic Laboratories during the study period.

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RADAR BRIDGE PATTERNS EXTRACTION AND RECOGNITION

INTRODUCTION

The objective of this study is to devise a feature extractor for extracting various bridge patterns from radar imagery. This extractor can be used in conjunction with other feature extractors developed earlier, for example, the feature extractor using Walsh transforms for recognizing road intersections, line roads, and rectangular objects[1] and the feature extractor employing image statistics for classifying a set of imagery such as city, water, field and forest.[2]

The technique presented makes use of a combination of the Hough transform, the Sobel edge operator, image thresholding methods, and decision logics to detect and recognize bridge candidate patterns that are, in general, characterized by a pair of long lines that are relatively close to each other.

The hardware system consists of a 32-element by 32-element solid-state array to convert the bridge patterns into electronic signals, a minicomputer to process the electronic signals from the array using a controlled software, and a computer-controlled, two-dimensional stage as the image holder. The majority of the bridge detection and recognition routines have been implemented as software for the hardware system described.

The description of the system operation is followed by an explanation of the strategies of bridge detection and recognition and bridge orientation angle determination. The system test results are discussed and conclusions presented.

SYSTEM DESCRIPTION

The block diagram of the system is shown in figure 1. A 9- by 9-inch glass plate mounted with various 2- by 2-inch cut radar imagery is illuminated by a light source, and a section of the image containing a

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[1]P.F. Chen, F.W. Rohde, and W.W. Seemuller, Classification of Cartographic Features Through Walsh Transforms, U.S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., ETL-0290, April 1982, AD-116 731.

[2]P.F. Chen, Preliminary Radar Feature Extraction and Recognition Using Texture Measurement, U.S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., Research note in progress.

bridge pattern is projected onto the surface of a Reticon 32-element by 32-element solid-state array through an imaging lens. The array converts the optical energy of the bridge pattern into a video signal. The video signal is quantized into 10 bits of digital signals and sent to the Hewlett-Packard 2117F minicomputer for processing. The computer first takes in a frame of 32 by 32 pixels of the digitized signal. Each pixel is sequentially compared to an automatically set threshold value. It is set to a "1" if it is greater than the threshold value and to a "0" otherwise.

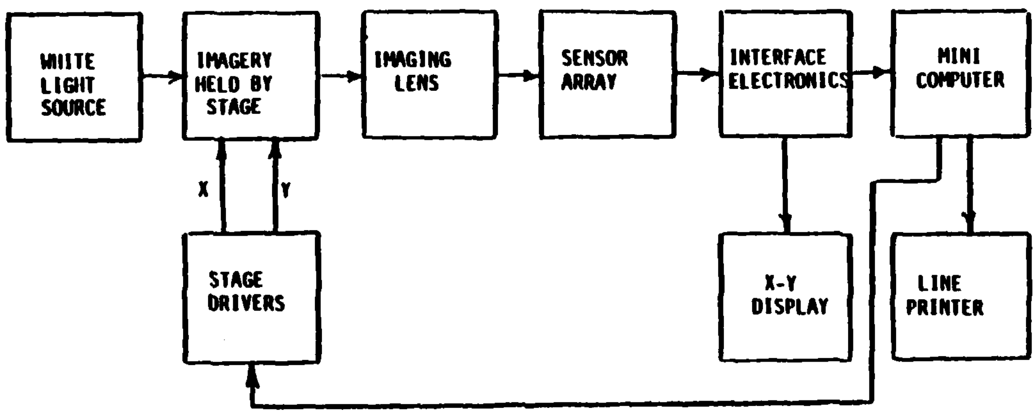

FIGURE 1. System Block Diagram.

The edges of the signal after thresholding are enhanced using the Sobel edge operator. The Hough transform of the edge-enhanced signal is then computed. The transformed matrix has a dimension of 64 by 32 and displays unique characteristics of a bridge. A recognition routine follows to screen out this unique characteristic and classifies the image as a bridge with its orientation angle against the X-axis of the measurement window (or the solid-state array). In case the unique characteristic is missing, the image is identified as "not a bridge." The recognition result is indicated on the CRT console. At the end of classification, the computer sends a signal to the translational stage controllers to move the stages in the predetermined x and y positions, and a new section of image is projected onto the surface of the solid-state array. The procedure described repeats until all preselected images are classified.

BRIDGE DETECTION AND RECOGNITION

As mentioned earlier, a candidate bridge pattern, in general, consists of a pair of long lines that are relatively close together. Thus, each possible bridge pattern is subjected to a set of tests that determine the pattern to be classified as either "a bridge" or "not a bridge."

The process involves at least the following four steps:

1. Preprocessing and thresholding to eliminate or reduce background and unwanted noise.

2. Edge detection to produce a pair of long, parallel lines.

3. Transformation of the long, parallel lines into a representation more easily identified by the computer.

4. Test to determine pattern as "a bridge" or "not a bridge."

To eliminate or reduce the background and unwanted noise, the incoming pixels were compared to an automatically set threshold value. The pixels that were greater than the threshold value were set equal to "1" and those that were less than or equal to the threshold value were set equal to "0." The threshold value was set equal to a half of the maximum pixel value within a given frame of pixels. With this method the unwanted background noise was eliminated in most of the cases.

The edge enhancement was accomplished by using a Sobel operator to produce a pair of long, parallel edge lines of the bridge pattern.[3] The Sobel operator, according to our past experience, has proved to be the best for generating clear and faithful image edges.

Detection of the pair of long, parallel lines produced by the Sobel operation in the spatial domain was relatively complicated. Therefore, the lines were transformed into the ρ and Θ domain using the Hough transform.[4] The Hough transform maps a line in Cartesian coordinate space (x and y spatial domain) into a point in polar coordinate space (ρ and Θ). A family of lines with different slopes, passing through a common point in the x-y domain, transforms into a connected set of ρ–Θ points. For our case, each edge point produced by the Sobel operator in

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[3] W.K. Pratt, Digital Image Processing, New York: John Wiley and sons, Inc., 1978.

[4] W.K. Pratt, Digital Image Processing, New York: John Wiley & Sons, Inc., 1978.

the x-y domain was transformed to a curve in the $\rho-\theta$ domain, which was quantized into cells. If an element of a curve fell in a cell, that particular cell was increased by one count. After all edge points were transformed, the $\rho-\theta$ cells were examined. Large cell counts correspond to colinear edge points that may be fitted by a straight line with the appropriate (ρ,θ) parameters.[5] The size of the transform matrix was selected to be 64 by 32 to yield enough resolution for determining the orientation of bridge patterns. The maximum available matrix size of the Hough transform is directly related to the size of the measurement window (input sampling array).

To determine the orientation angle of the bridge patterns against the X-axis of the measurement window, the 10 largest numbers were sorted in a decreasing magnitude order together with their indices (the I's and J's specifying the location of the transform element holding the sorted numbers) from the transform matrix. These 10 numbers were compared to a second threshold value, "ITT," which was automatically set equal to 0.75 of the maximum element value of the Hough transform. Only the numbers greater than "ITT" were screened and saved from recognition and detection of bridge patterns and their orientation angles.

The determination of the bridge orientation is as follows:

(a) First, the row number, J, of the largest screened number is found. If there is at least one other screened number in the same row, or in other words, having the same J, then that J is used for the computation of the bridge orientation angle.

(b) If the condition (a) is not met, then look for a new row with two or more screened numbers. Use that row number, J, for the computation of the bridge orientation angle.

(c) If neither condition (a) nor condition (b) is present then just use the row number, J, in which the maximum screened number resides for the computation of the bridge orientation angle.

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[5]W.K. Pratt, Digital Image Processing, New York: John Wiley & Sons, Inc., 1978.

(d) The formulas for the computation of bridge angle, R_1, are

$R_1 = 22.5\ (32-J)$ degrees; if $20 \leq J \leq 32$ (1)

$R_1 = 180 - 2.5\ J$ degrees; if $1 \leq J < 20$ (2)

The test for deciding whether a pattern belongs to the category of a bridge is as follows: Since a bridge pattern always displays some width in its appearance in radar imagery, each pixel, after first thresholding in the measurement window, is tested for coexistence with its neighbors. As indicated before, the measurement window after first thresholding contains pixels of only two values, either a "1" or a "0". Thus, if a pixel itself is a "1" and its left-hand neighbor is also a "1", a row count will be made. Similarly, if a pixel is a "1" and the pixel just below it is also a "1", then a column count will be made. The row and column counts are examined after the tests are made for all pixels in the measurement window. A flag is set if any one of these two counts is greater than eight. This flag is designated as "ANS." This flag, together with the existence of one of the first three conditions stated in the previous paragraph, constitutes the absolute requirement for recognizing and detecting bridge patterns and their orientation angles.

SYSTEM TEST RESULTS

A set of high quality, scale of 1 to 100,000, X-band synthetic aperture radar imagery from the Hudson River, New York State, area consisting of bridge images (transportation DLMS category number 503, FIC 260) was used for this experimentation.

Figures 2(a) to 9(a) show the line printer output of bridge patterns with different orientation angles. Each pattern is printed in 16 gray shades by line printing. Figures 2(b) through 9(b) show the recognition results of bridges at various orientation angles. The Hough transform for these bridge patterns is illustrated in figures 2(c) to 9(c). It is seen that each bridge pattern was recognized properly and its orientation angle identified correctly. Figures 10(a), 10(b), and 10(c) demonstrate the input image, the recognition result, and the Hough transform when the measurement window sampled an entirely black area. As expected, the system recognized this image as "not a bridge." The resolution of the bridge detection with present system setup is approximately 22.5 degrees. This resolution can be increased by using a larger size measurement window. Figures 11 and 12 illustrate the bridge-recognition results for the case of using 64- by 64- pixels measurement window. As expected, the bridge-detection resolution was increased to approximately 10 degrees.

It was discovered that the bridge orientation angle determination was less accurate for bridge patterns oriented at 45 degrees and 135 degrees than for other orientations. This is due to the quantization error of the small-size measurement window (32 by 32 pixels for our case) that distorts the straight bridge-edge lines into looking like staircase patterns at 45 degrees and 135 degrees, especially when the patterns shift their position from one corner of the measurement window to the other. This error can be reduced if the size of the measurement window is enlarged at the cost of increased processing time. The software listing for this study is included as an appendix.

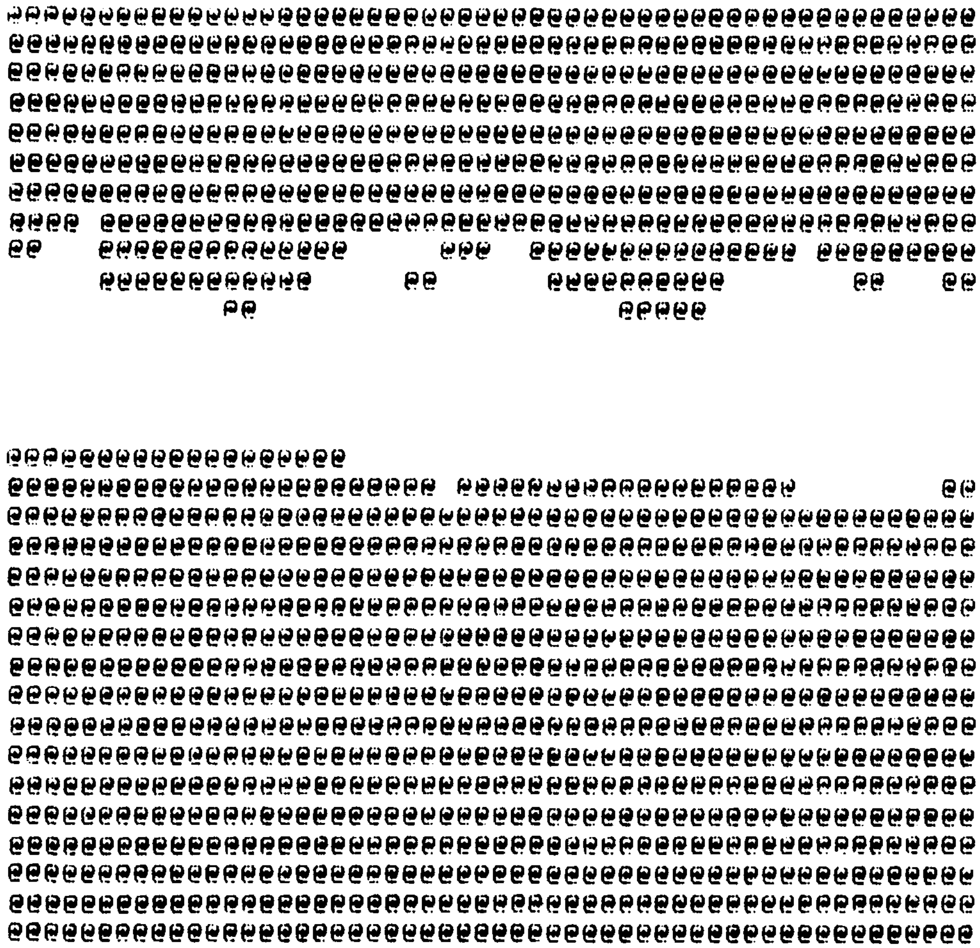
CONCLUSIONS

1. The Hough transform, together with the Sobel edge operator, image-thresholding methods, and decision logics, provides an effective means for detecting and recognizing various bridge patterns and their orientation angles from a set of radar imagery of the Hudson River, New York State, area.

2. The entire set of the selected radar bridge image patterns was recognized correctly with this scheme even if the bridges were not centered in the measurement window.

3. The resolution of bridge orientation angle determination with a 32- by 32-pixels measurement window is approximately 22.5 degrees. The resolution can be increased by enlarging the measurement window size as demonstrated in the report.

4. The quantization error of the measurement window can also be reduced by using a larger window size at the cost of increasing the processing time.



(a) Pictorial Print of Processed Input Image.

```
IROW =  30
ICOL =   3
ANS =    1
ITT -   22.
J =     32
R1 =     0.0
Bridge Detected at 0.0 Degrees with X-Axis.
```

FIGURE 2. (b) Recognition Result of Bridge Pattern at 0 Degree.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	22	26	11	8	3	15	24	27	17	6	3	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	4	26	26	12	4	10	16	21	16	10	9	6	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	10	10	22	17	13	10	16	10	12	10	7	6
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8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2	4	8	7	12	10	7	10
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	7	4	12	5	6	12
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2	5	6	8	6	6
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2	6	6	5	8
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	5	7	5
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	5	6
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	5
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	6	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	8	7	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	7	7	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	8	7	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	8	4	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	6	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25	3	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
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32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

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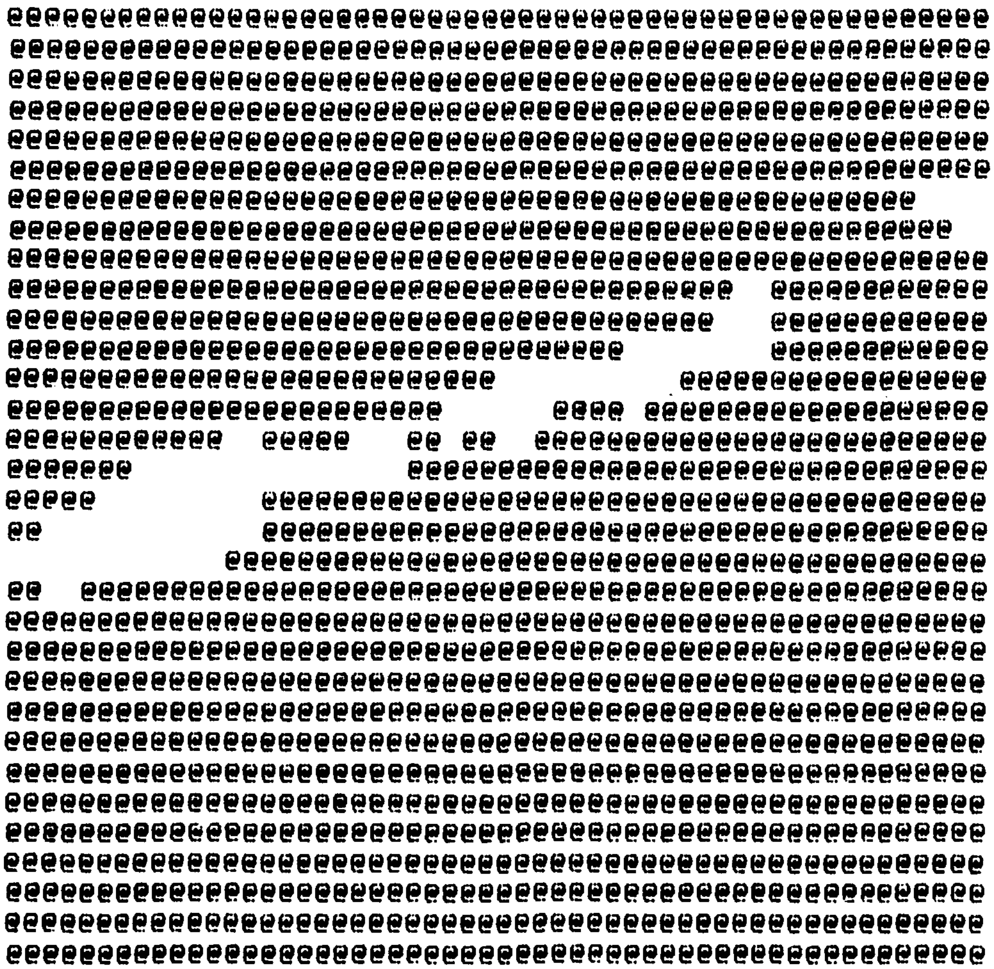
0	0	0	0	0	0	0	2	5	5	4	11	8	9	13	12	11	17	12	9	9	9	5	6	6	6	4	0	0	0	0	0	29
0	0	0	0	0	0	0	2	5	5	7	16	15	10	9	23	11	10	8	11	8	6	7	7	3	0	0	0	0	0	0	0	30
0	0	0	0	0	0	0	3	5	6	19	19	10	14	9	14	10	8	12	11	6	8	1	0	0	0	0	0	0	0	0	0	31
0	0	0	0	0	0	0	8	10	17	30	23	5	2	10	13	16	17	8	4	0	0	0	0	0	0	0	0	0	0	0	0	32

FIGURE 2. (c) Hough Transform of Bridge Pattern at 0 Degree.



(a) Pictorial Print of Processed Input Image.

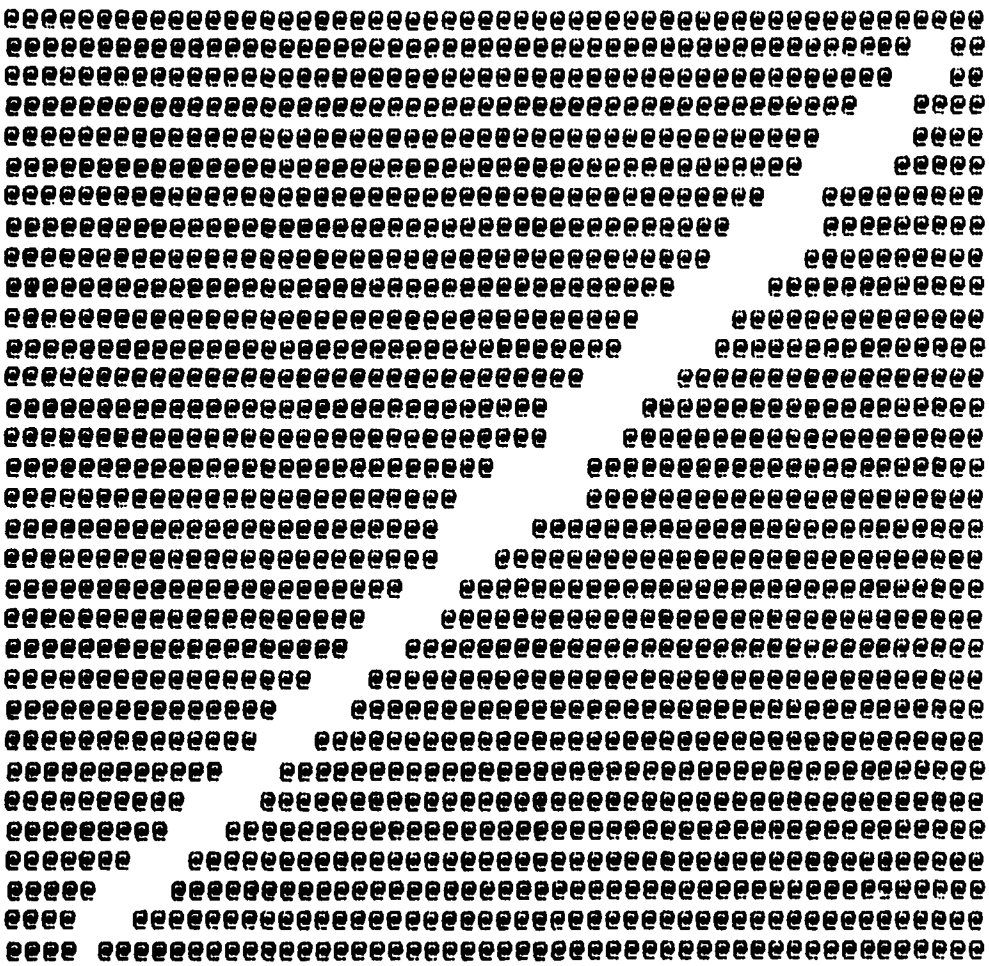
```
IROW = 9
ICOL = 7
ANS =  1
ITT - 22.
J =   31
R1 =    22.5
Bridge Detected at 22.5 Degrees with X-Axis.
```

FIGURE 3. (b) Recognition Result of Bridge Pattern at 22.5 Degrees.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	11	11	12	12	16	19	15	12	5	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	4	7	10	12	12	13	13	15	13	13	4	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	6	6	8	3	14	14	13	14	11	10	8	5	4	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	3	6	4	7	2	10	11	14	13	11	10	6	4	6	5	4
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	4	5	4	6	4	8	8	12	9	11	8	8	8	3	4
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	4	4	4	4	6	8	6	9	10	7	7	9	4	6
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	4	4	4	7	6	6	8	7	9	5	7	5
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	3	4	5	5	6	6	7	6	8	6	7
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	2	2	6	5	8	4	8	4	4	10
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	4	3	4	6	7	4	5	7	4
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	4	2	5	4	7	6	4	6
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	3	3	7	5	6	4
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2	3	4	5	6	6
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	4	5	7
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	5
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	5	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	5	4	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	4	5	4	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	5	5	3	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	4	5	3	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	5	2	3	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25	3	2	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	1	5	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	5	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
5	4	4	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
6	3	4	5	4	4	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
3	6	4	5	6	3	4	3	4	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
4	4	2	5	4	5	2	7	4	3	3	4	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8
4	7	3	3	3	2	5	3	5	3	3	7	2	5	2	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9
7	6	4	6	3	3	3	2	2	4	4	2	6	3	4	4	4	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	10
4	6	7	4	5	3	4	4	1	3	2	2	4	2	4	4	4	5	3	4	3	1	0	0	0	0	0	0	9	0	0	0	11
6	5	4	5	6	5	3	3	5	3	1	2	3	2	2	3	4	3	4	3	5	4	3	2	1	0	0	0	0	0	0	0	12
5	5	4	5	6	4	4	4	3	5	3	3	1	2	3	2	2	2	3	4	4	3	3	6	4	2	1	0	0	0	0	0	13
4	5	5	4	5	5	6	4	4	3	3	4	4	3	1	2	2	2	2	2	3	3	3	4	3	5	6	2	1	0	0	0	14
6	5	5	5	6	5	4	6	4	4	3	3	4	4	3	2	2	2	2	2	2	2	3	3	3	4	4	5	5	2	0	0	15
5	6	5	5	5	6	5	4	5	4	4	3	3	3	4	3	3	2	2	2	2	2	2	2	3	3	3	4	4	5	5	2	16
0	5	6	6	6	4	5	7	4	4	5	4	3	3	3	4	4	3	2	2	2	2	2	2	2	3	2	3	3	5	4	5	17
0	0	2	6	6	7	5	4	7	5	4	5	5	3	3	3	4	4	3	2	2	2	2	2	2	2	3	2	2	3	4	5	18
0	0	0	2	6	5	7	5	4	6	6	4	4	5	3	4	3	4	4	4	2	2	2	2	2	2	2	3	2	2	4	4	19
0	0	0	0	2	3	5	7	7	5	6	6	5	4	4	3	3	4	4	4	4	2	2	2	2	3	2	3	3	2	2	4	20
0	0	0	0	0	1	4	4	7	7	7	5	6	4	5	4	4	3	4	4	4	3	3	3	2	2	3	2	3	2	3	3	21
0	0	0	0	0	0	2	4	3	6	8	8	5	6	4	5	4	3	4	5	4	4	4	2	2	2	4	2	3	3	3	3	22
0	0	0	0	0	0	0	3	3	3	5	9	10	4	7	3	5	5	3	5	4	5	4	3	2	2	4	3	3	3	4	3	23
0	0	0	0	0	0	0	0	3	4	3	5	10	9	5	5	5	5	5	4	6	5	4	3	3	3	3	3	4	4	4	3	24
0	0	0	0	0	0	0	0	2	3	2	7	4	12	5	4	8	4	8	4	4	7	4	5	2	5	3	3	6	3	5	0	25
0	0	0	0	0	0	0	0	0	2	4	5	6	7	6	7	7	6	7	7	7	5	5	4	4	4	6	4	5	2	0	1	26
0	0	0	0	0	0	0	0	0	1	3	6	8	4	4	5	10	9	8	9	5	8	6	3	7	5	6	3	8	8	2	6	27
0	0	0	0	0	0	0	0	0	0	3	5	9	6	8	5	10	11	13	9	9	8	6	8	5	3	8	8	8	6	3	0	28
0	0	0	0	0	0	0	0	0	0	2	7	10	4	8	3	12	14	16	12	12	10	6	2	8	8	8	6	3	0	0	0	29
0	0	0	0	0	0	0	0	0	0	2	8	11	2	8	3	17	10	27	15	7	8	8	8	1	6	2	0	0	0	0	0	30
0	0	0	0	0	0	0	0	0	0	4	10	8	1	8	16	29	30	12	8	8	8	3	6	0	0	0	0	0	0	0	0	31
0	0	0	0	0	0	0	0	0	0	9	8	6	8	21	27	16	10	5	2	4	3	0	0	0	0	0	0	0	0	0	0	32

FIGURE 3. (c) Hough Transform of Bridge Pattern at 22.5 Degrees.



(a) Pictorial Print of Processed Input Image.

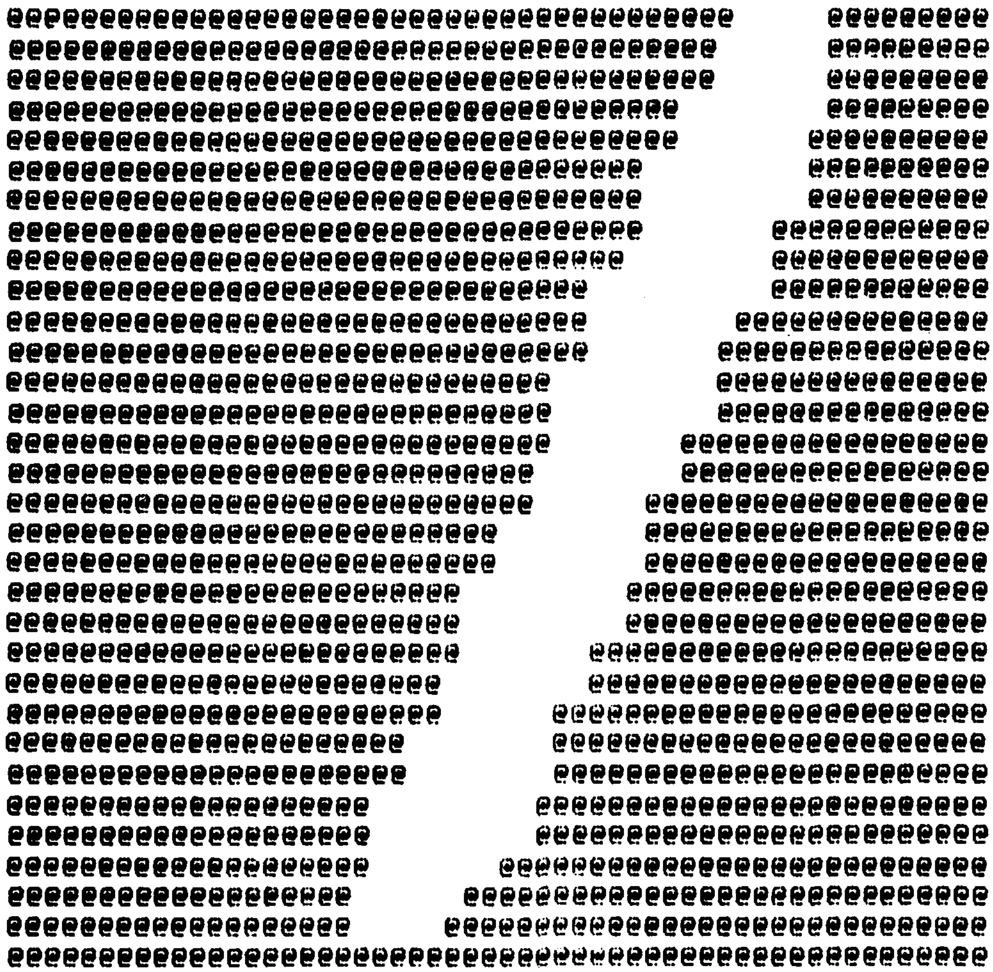
IROW = 14
ICOL = 12
ANS = 1
ITT - 22.
J = 30
R1 = 45.0
Bridge Detected at 45.0 Degrees with X-Axis.

FIGURE 4. (b) Recognition Result of Bridge Pattern at 45 Degrees.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
1	0	0	0	0	6	6	6	6	6	6	7	8	8	6	6	6	5	6	5	6	8	10	7	7	7	5	6	6	5	4	3	2
2	0	0	0	0	0	6	4	4	4	6	7	6	6	9	11	0	4	3	4	6	7	7	7	8	12	9	3	4	4	6	5	3
3	0	0	0	0	0	0	4	3	5	3	3	6	6	8	7	9	8	7	7	3	5	6	8	6	8	9	8	9	5	4	3	5
4	0	0	0	0	0	0	0	1	4	3	3	5	5	5	6	7	7	6	7	6	7	7	9	7	7	5	6	8	8	5	7	6
5	0	0	0	0	0	0	0	0	0	2	3	3	4	5	5	6	5	6	6	5	6	7	8	8	11	6	7	5	8	4	8	4
6	0	0	0	0	0	0	0	0	0	0	0	2	3	4	4	5	4	5	6	5	6	4	8	6	10	7	8	8	5	11	4	7
7	0	0	0	0	0	0	0	0	0	0	0	0	0	2	3	4	5	3	5	5	5	5	4	8	6	9	7	6	8	6	8	9
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	3	4	5	3	5	5	3	7	6	5	10	5	6	9	3	10
9	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	5	3	5	3	4	6	5	10	4	9	5	4	9
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	3	3	3	4	4	5	7	6	6	7	6	6
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	4	2	3	7	5	6	8	5	5
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	3	2	4	6	8	4	7
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	2	3	5	5	8
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	3	3	5
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	4
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	4	4	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	5	4	4	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	4	5	4	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	6	4	4	2	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	7	5	2	4	2	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	6	4	3	3	3	4	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25	5	3	3	4	3	5	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	3	6	3	6	3	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	5	5	6	6	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	8	6	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29	11	7	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
1	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
3	2	4	2	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
4	3	3	3	3	1	3	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
6	6	5	5	3	3	2	2	2	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
4	6	4	5	6	5	5	2	2	2	2	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
6	8	2	6	6	3	6	3	6	5	2	2	1	2	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
6	6	9	5	7	5	4	6	4	4	5	4	4	2	2	1	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	8
4	10	5	4	10	4	9	4	8	4	3	5	4	5	3	3	3	1	2	0	1	1	0	0	0	0	0	0	0	0	0	0	9
6	6	5	8	6	5	7	7	5	6	6	6	6	4	4	4	4	3	4	1	2	0	1	1	0	0	0	0	0	0	0	0	10
6	6	6	6	6	5	8	6	4	8	5	5	8	4	6	7	3	5	4	2	4	3	1	0	2	0	0	0	0	0	0	0	11
5	6	5	7	5	7	6	6	5	6	6	6	5	6	6	5	6	6	6	4	4	3	3	3	2	1	1	0	0	0	0	0	12
5	5	6	5	6	6	6	7	6	5	5	6	7	5	5	6	5	7	5	6	5	5	5	4	3	3	2	1	0	0	0	0	13
6	5	6	6	5	5	6	6	7	6	6	4	6	6	5	7	6	4	7	6	5	6	6	3	6	5	3	3	2	0	0	0	14
4	5	5	5	5	6	6	6	6	7	4	6	5	5	6	5	7	6	5	6	6	6	6	6	5	6	4	6	3	3	0	0	15
4	5	3	4	5	5	5	6	6	6	7	6	6	6	6	6	5	5	6	4	6	5	6	6	5	5	6	5	5	5	5	2	16
0	4	5	4	3	4	4	5	5	5	6	7	6	6	6	6	6	6	6	6	6	6	6	6	6	5	6	5	5	5	5	4	17
0	0	2	5	4	4	3	4	4	4	5	5	6	6	6	7	7	7	8	7	6	6	6	6	6	5	6	5	5	5	5	4	18
0	0	0	2	3	4	4	4	3	5	4	5	6	6	6	6	6	6	6	6	7	7	6	8	7	6	6	5	5	5	5	4	19
0	0	0	0	2	3	2	5	4	4	5	4	4	6	5	6	6	6	7	6	8	6	7	8	7	7	6	6	5	5	6	4	20
0	0	0	0	0	1	4	2	3	5	4	4	4	5	6	5	4	7	5	8	8	7	8	6	8	7	5	7	6	5	7	4	21
0	0	0	0	0	0	2	4	2	2	4	6	4	7	5	5	6	6	5	6	8	6	8	9	7	6	9	5	6	6	6	4	22
0	0	0	0	0	0	0	3	3	4	2	4	4	6	7	5	6	8	4	8	4	9	7	7	7	8	6	8	5	7	5	7	23
0	0	0	0	0	0	0	0	3	5	3	4	3	4	7	6	7	7	8	6	8	7	6	7	5	7	5	9	7	7	7	7	24
0	0	0	0	0	0	0	0	2	3	4	6	3	6	4	2	12	6	11	6	6	10	5	6	2	8	6	5	12	6	10	3	25
0	0	0	0	0	0	0	0	0	2	6	5	6	5	6	6	5	8	12	8	7	5	6	5	6	5	7	8	9	6	5	5	26
0	0	0	0	0	0	0	0	0	1	4	8	9	6	9	6	8	6	3	8	5	9	8	6	8	7	7	3	3	6	6	0	27
0	0	0	0	0	0	0	0	0	0	4	9	14	12	12	6	0	0	0	5	10	13	11	13	9	2	0	0	2	6	10	11	28
0	0	0	0	0	0	0	0	0	0	4	17	27	9	0	0	0	0	0	2	17	26	17	1	0	0	0	0	0	9	21	16	29
0	0	0	0	0	0	0	0	0	2	25	22	0	0	0	0	0	0	0	10	29	16	0	0	0	0	0	0	6	27	16	0	30
0	0	0	0	0	0	0	6	9	14	14	10	4	0	0	0	4	12	12	13	14	7	1	0	0	0	6	13	15	13	2	0	31
0	0	0	0	2	6	6	8	8	9	9	7	2	2	7	9	7	7	9	8	9	4	1	2	7	9	8	9	0	6	0	0	32

FIGURE 4. (c) Hough Transform of Bridge Pattern at 45 Degrees.



(a) Pictorial Print of Processed Input Image.

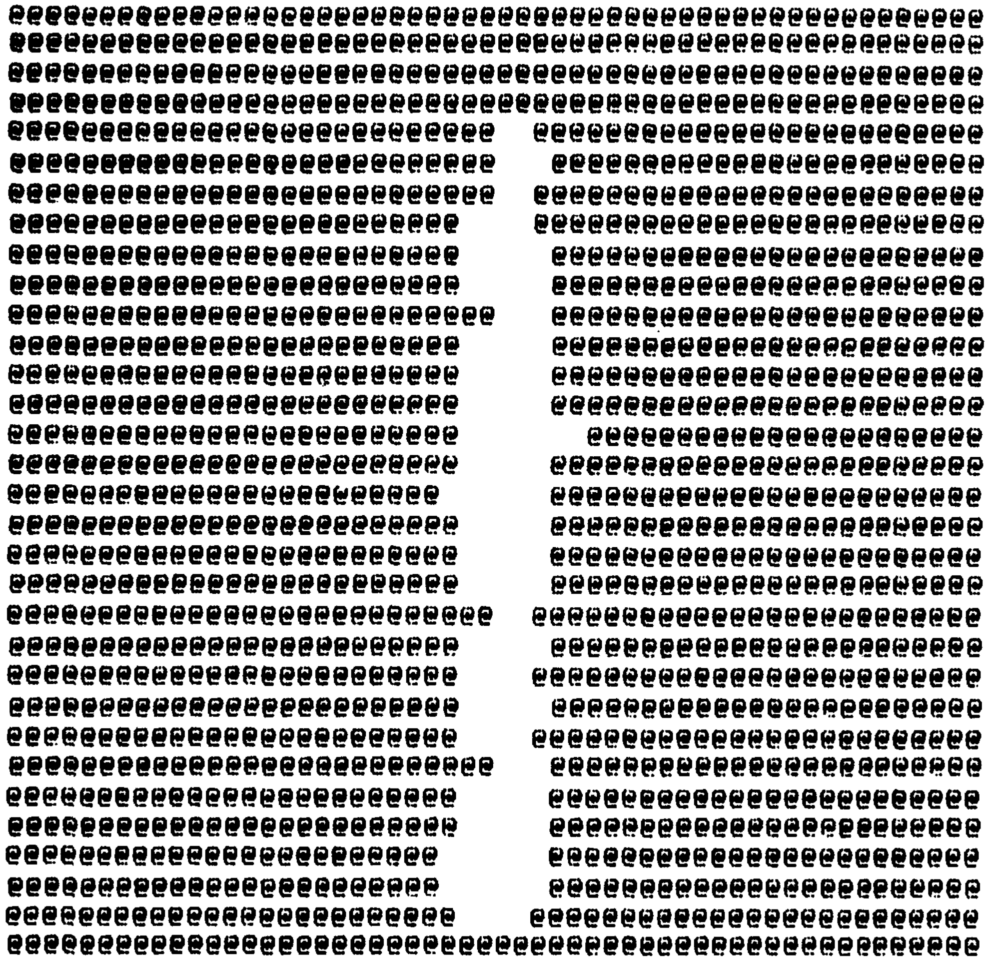
```
IROW = 15
ICOL = 30
ANS =   1
ITT -  22.
J =    29
R1 =    67.5
Bridge Detected at 67.5 Degrees with X-Axis.
```

FIGURE 5. (b) Recognition Result of Bridge Pattern at 67.5 Degrees.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
1	0	0	0	0	5	5	7	5	8	8	8	6	6	6	6	5	5	5	6	6	8	8	8	5	5	6	6	5	5	6	5	5
2	0	0	0	0	0	0	5	5	6	6	9	10	9	8	5	4	4	4	5	5	6	8	7	10	8	7	6	5	4	2	5	6
3	0	0	0	0	0	0	0	0	4	5	7	9	8	7	8	9	7	5	4	3	5	4	8	9	6	9	8	8	6	4	4	3
4	0	0	0	0	0	0	0	0	0	1	4	7	5	8	6	9	7	5	10	5	6	5	6	7	5	7	8	5	8	7	7	6
5	0	0	0	0	0	0	0	0	0	0	1	2	4	5	7	4	9	4	9	3	9	6	10	7	7	7	3	9	4	8	3	9
6	0	0	0	0	0	0	0	0	0	0	0	1	2	2	4	4	5	5	5	6	7	5	8	6	11	8	10	4	8	2	9	5
7	0	0	0	0	0	0	0	0	0	0	0	0	0	3	1	4	2	3	3	5	6	4	6	8	7	10	7	7	8	7	7	8
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	3	3	2	3	2	4	4	5	8	6	11	3	10	6	9	7
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	1	2	3	2	4	1	2	5	5	11	5	8	5	5	11
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	1	3	2	2	4	1	4	5	6	6	4	9	3
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	2	2	2	3	2	3	5	5	5	3	8
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	2	2	1	3	4	5	5	4	4
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	3	2	1	4	5	5	5
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	3	2	6	4
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	2	5
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	4	4	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	7	4	3	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	5	6	5	2	2	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	7	6	3	5	2	3	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	7	7	4	2	6	2	2	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	6	4	4	4	4	4	4	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25	5	3	5	4	4	5	5	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	1	5	2	8	4	8	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	1	3	4	8	7	6	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	8	4	7	8	9	5	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29	8	9	12	9	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	9	13	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31	15	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
5	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
3	5	4	2	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
4	2	4	3	5	2	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
6	7	4	3	5	2	4	2	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
7	3	8	4	8	2	6	2	4	1	4	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
4	6	6	6	5	4	6	4	5	6	3	1	3	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
7	7	4	9	6	5	4	4	6	4	7	3	6	1	4	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8
5	10	4	4	9	6	11	5	6	2	2	8	4	8	2	2	5	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	9
9	8	5	9	4	7	8	6	7	5	9	5	3	5	6	5	5	2	5	2	1	0	0	0	0	0	0	0	0	0	0	0	10
4	7	8	5	8	4	8	6	7	6	6	7	8	4	8	4	5	7	2	5	4	2	1	0	0	0	0	0	0	0	0	0	11
4	5	5	6	7	6	5	7	7	6	7	5	7	6	7	7	6	7	6	4	5	4	3	3	1	0	0	0	0	0	0	0	12
3	4	4	7	3	5	5	7	6	6	7	6	7	5	5	7	8	7	6	7	6	6	5	3	3	3	1	0	0	0	0	0	13
5	3	4	5	5	5	4	4	5	6	6	7	5	6	7	6	5	6	7	8	9	4	6	6	7	3	3	2	1	0	0	0	14
5	4	5	4	4	5	6	5	4	3	4	6	6	6	6	5	6	7	5	7	8	7	6	7	6	6	6	5	2	2	0	0	15
5	5	4	5	5	4	5	5	5	5	4	4	5	6	6	4	6	6	5	5	7	8	7	5	7	6	6	5	6	4	4	2	16
0	6	5	4	4	5	5	5	5	4	5	5	4	5	5	5	5	5	5	6	7	7	6	7	8	6	5	6	6	5	4	4	17
0	0	3	6	4	4	4	5	6	5	4	4	5	6	5	5	4	7	5	4	6	7	6	7	7	7	6	6	4	6	6	4	18
0	0	0	3	3	4	4	6	4	7	5	5	4	4	8	5	6	4	5	6	5	5	5	6	6	8	6	5	5	5	5	6	19
0	0	0	0	3	3	3	3	5	5	6	6	6	5	6	6	7	4	5	5	7	6	5	5	5	6	6	5	5	4	6	7	20
0	0	0	0	0	2	4	3	3	3	8	4	7	6	6	6	6	7	4	8	5	8	4	7	4	3	5	4	6	5	6	5	21
0	0	0	0	0	0	3	4	2	4	4	5	5	8	5	7	7	7	6	8	8	4	7	7	3	4	4	3	4	5	6	5	22
0	0	0	0	0	0	1	3	4	4	2	6	4	3	8	7	8	8	8	8	7	8	6	5	4	3	4	4	4	4	4	8	23
0	0	0	0	0	0	0	1	3	5	5	5	4	4	5	7	8	9	10	7	8	7	5	5	4	5	4	5	5	5	4	4	24
0	0	0	0	0	0	0	0	3	4	4	8	4	8	4	4	9	6	13	6	5	8	4	8	4	8	4	4	8	4	5	0	25
0	0	0	0	0	0	0	0	1	3	7	7	7	8	8	7	6	5	4	5	7	7	7	8	7	8	8	7	6	2	0	0	26
0	0	0	0	0	0	0	0	0	2	7	12	12	8	11	6	2	0	0	2	5	11	12	10	12	9	10	4	0	0	0	0	27
0	0	0	0	0	0	0	0	0	1	10	15	21	11	2	0	0	0	0	0	4	9	10	23	14	7	0	0	0	0	0	0	28
0	0	0	0	0	0	0	0	0	0	27	22	11	0	0	0	0	0	0	0	0	26	23	26	0	0	0	0	0	0	0	0	29
0	0	0	0	0	0	0	0	9	17	19	11	4	0	0	0	0	0	0	10	16	23	14	11	1	0	0	0	0	0	4	10	30
0	0	0	0	0	1	8	10	11	10	10	7	3	0	0	0	4	0	11	10	10	11	11	7	3	0	0	0	5	7	12	9	31
0	0	0	3	7	6	8	7	7	7	7	6	2	2	5	8	9	6	7	7	8	8	8	5	2	2	5	7	9	6	5	8	32

FIGURE 5. (c) Hough Transform of Bridge Pattern at 67.5 Degree.



(a) Pictorial Print of Processed Input Image.

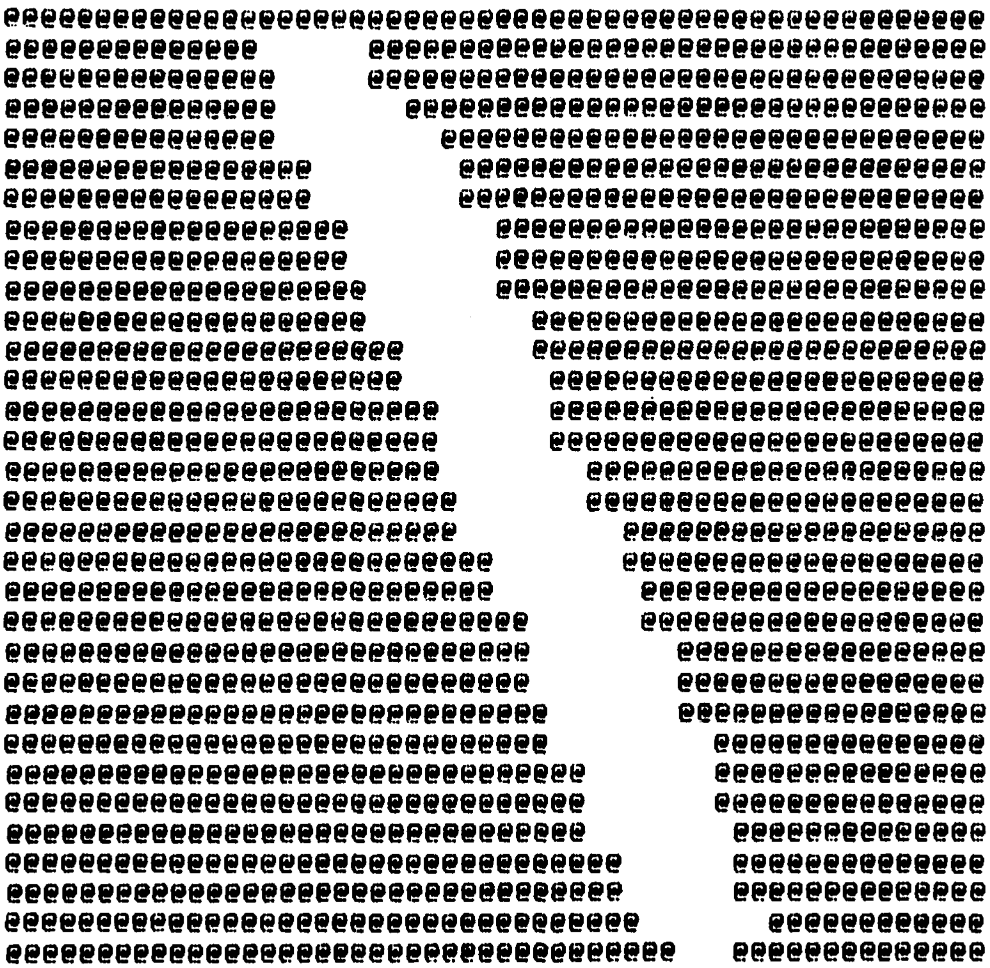
IROW = 2
ICOL = 13
ANS = 1
ITT - 22.
J = 28
R1 = 90.0
Bridge Detected at 90.0 Degrees with X-Axis.

FIGURE 6. (b) Recognition Result of Bridge Pattern at 90 Degrees.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
1	0	0	0	0	5	5	5	7	7	7	6	6	6	6	5	5	5	4	4	5	5	5	7	7	6	4	4	4	3	3	0	0
2	0	0	0	0	0	0	5	4	5	7	11	9	7	6	6	5	2	4	4	4	4	4	5	5	8	8	7	6	4	3	3	0
3	0	0	0	0	0	0	0	0	2	6	9	7	7	9	9	7	6	3	4	3	4	3	3	5	5	8	7	7	6	8	5	1
4	0	0	0	0	0	0	0	0	1	1	2	6	7	8	6	7	9	7	7	5	3	3	4	3	5	6	5	7	6	4	7	6
5	0	0	0	0	0	0	0	0	0	1	1	2	4	3	6	7	6	6	6	8	6	7	4	6	6	3	6	4	6	4	6	6
6	0	0	0	0	0	0	0	0	0	0	1	1	2	2	5	3	3	5	5	7	7	5	5	6	6	10	7	5	4	4	7	3
7	0	0	0	0	0	0	0	0	0	0	0	0	1	3	1	4	3	3	3	3	5	6	5	6	6	5	9	6	9	6	6	6
8	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	3	2	3	3	3	3	3	3	3	6	5	10	5	6	6	8	7
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	1	2	4	2	4	2	2	4	2	7	5	9	6	2	11
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	1	3	3	2	4	2	3	4	3	7	3	7	6
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	2	2	3	3	2	3	3	6	4	4	6
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	2	2	2	3	3	4	4	5	5
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	3	2	2	3	4	6	3
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	2	3	2	5	4
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	2	2	5
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	5	5	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	6	5	3	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	5	6	3	3	3	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	7	6	2	4	3	4	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	6	4	3	2	5	3	4	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	2	2	3	3	4	5	3	5	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25	0	1	2	3	6	4	5	5	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	0	0	1	5	4	8	4	4	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	0	0	1	4	7	7	7	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	0	0	1	5	10	9	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29	0	0	5	11	10	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	0	8	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31	9	13	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
5	5	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
2	7	5	4	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
6	2	6	5	4	3	3	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
3	6	2	6	3	5	2	3	3	3	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
7	6	5	5	3	5	3	4	2	3	2	4	2	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8
2	11	4	4	9	3	9	2	5	1	2	3	2	4	2	2	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9
4	7	7	5	5	6	6	7	5	6	4	2	3	2	1	4	2	3	2	2	1	0	0	0	0	0	0	0	0	0	0	0	10
3	6	4	6	6	5	7	4	6	6	5	5	5	4	3	2	3	2	3	3	2	2	2	0	0	0	0	0	0	0	0	0	11
5	3	5	5	4	4	5	6	6	6	4	4	5	5	4	4	6	4	3	1	4	2	2	2	3	0	0	0	0	0	0	0	12
5	4	5	5	3	6	3	3	4	4	6	7	4	3	5	4	4	5	5	5	5	2	3	3	2	2	2	1	0	0	0	0	13
4	4	5	5	5	5	4	4	4	3	3	4	4	5	4	5	4	3	4	5	6	4	5	3	5	3	2	3	2	0	0	0	14
5	3	5	4	5	5	5	5	4	5	2	4	3	3	3	3	4	4	5	5	3	5	4	5	4	4	7	4	2	2	2	0	15
6	4	5	5	5	5	5	5	4	4	4	4	4	3	3	3	1	3	3	4	3	6	4	5	4	5	5	5	6	4	4	2	16
0	6	5	4	5	5	5	5	5	4	5	4	5	4	3	2	2	3	2	2	3	3	5	4	6	4	5	4	6	6	4	6	17
0	0	3	5	5	4	5	6	5	5	5	4	5	4	4	3	3	2	3	3	2	2	2	4	3	5	5	6	4	6	6	5	18
0	0	0	3	3	4	6	5	5	5	4	5	5	6	9	4	3	2	2	2	4	2	2	2	4	3	4	5	5	6	6	5	19
0	0	0	1	3	3	2	3	7	5	4	6	5	7	4	4	4	3	3	3	2	4	2	3	2	4	3	3	5	5	5	7	20
0	0	0	0	2	4	2	3	3	2	6	5	6	6	4	5	4	4	4	4	3	3	3	3	3	3	3	4	3	4	5	5	21
0	0	0	0	0	2	5	3	2	4	2	2	6	7	4	4	5	5	4	5	4	4	3	4	2	3	5	4	3	5	3	5	22
0	0	0	0	0	1	4	4	3	4	2	3	3	1	4	5	5	6	5	6	4	5	4	3	4	4	5	5	5	4	5	3	23
0	0	0	0	0	0	2	5	5	4	3	3	2	1	0	1	5	6	6	6	7	7	5	4	5	5	6	5	5	5	5	0	24
0	0	0	0	0	0	1	3	9	3	3	5	1	0	0	0	0	2	10	5	6	12	5	9	4	10	5	4	9	2	0	0	25
0	0	0	0	0	0	0	3	8	6	5	3	0	0	0	0	0	0	2	6	11	12	11	9	9	10	8	5	0	0	0	0	26
0	0	0	0	0	0	0	2	7	12	4	0	0	0	0	0	0	0	0	1	7	19	20	13	15	7	1	0	0	0	0	0	27
0	0	0	0	0	0	0	0	12	13	0	0	0	0	0	0	0	0	0	0	3	29	27	24	0	0	0	0	0	0	0	0	28
0	0	0	0	0	0	0	3	15	6	1	0	0	0	0	0	0	0	0	5	21	24	23	10	0	0	0	0	0	0	0	0	29
0	0	0	0	0	0	1	10	9	4	1	0	0	0	0	0	0	0	11	13	11	16	13	9	2	0	0	0	0	0	0	5	30
0	0	0	0	0	2	6	7	6	3	1	0	0	0	4	0	9	0	6	8	10	9	10	7	3	1	0	0	0	5	9	9	31
0	0	0	0	3	3	5	6	5	2	1	2	5	9	6	6	5	5	7	6	7	8	8	6	2	1	2	6	7	8	5	8	32

FIGURE 6. (c) Hough Transform of Bridge Pattern at 90 Degrees.



(a) Pictorial Print of Processed Input Image.

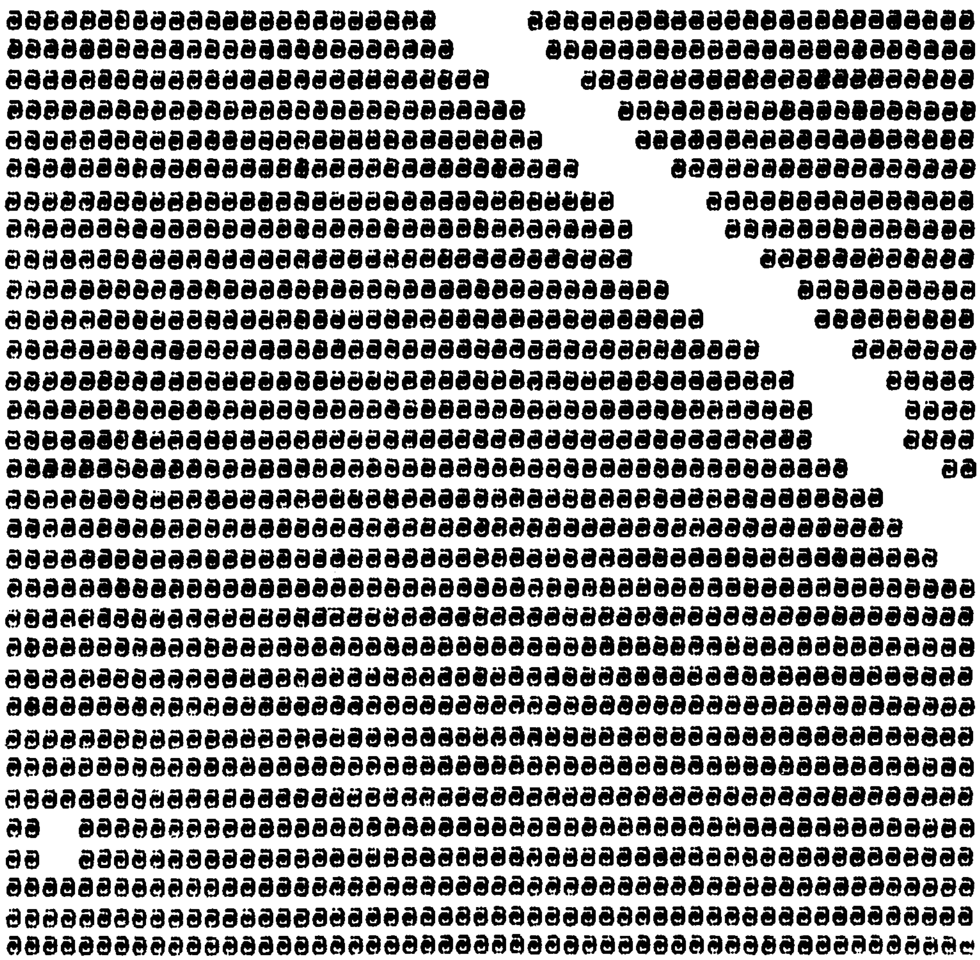
```
IROW = 15
ICOL = 30
ANS =   1
ITT -  29.
J =    27
R1 =  12.5
Bridge Detected at 112.5 Degrees with X-Axis.
```

FIGURE 7. (b) Recognition Result of Bridge Pattern at 112.5 Degrees.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
1	0	0	0	0	0	7	5	7	7	6	6	5	5	6	6	6	6	6	6	5	5	6	6	7	7	6	7	7	8	6	6	6
2	0	0	0	0	1	2	1	9	11	7	9	6	5	5	4	5	6	4	5	6	6	4	4	6	8	7	7	9	9	8	8	6
3	0	0	0	0	0	1	2	2	3	5	11	9	8	5	6	6	5	4	4	6	5	3	5	5	6	4	9	9	10	9	8	9
4	0	0	0	0	0	1	1	1	3	2	4	6	5	5	11	8	4	7	6	4	3	6	5	2	6	7	5	6	9	10	6	10
5	0	0	0	0	0	0	0	2	1	2	3	4	3	5	4	3	6	7	8	7	6	7	3	5	6	4	6	7	6	9	6	8
6	0	0	0	0	0	0	0	0	1	2	2	2	4	2	5	5	2	4	2	5	6	7	7	8	5	8	6	6	5	8	9	6
7	0	0	0	0	0	0	0	0	0	1	1	1	2	4	2	4	5	3	3	3	3	3	3	5	5	10	10	6	11	6	8	6
8	0	0	0	0	0	0	0	0	0	0	0	1	2	1	3	3	3	3	3	4	3	3	3	3	3	3	7	6	8	9	10	12
9	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	1	4	2	2	5	2	5	2	2	4	2	5	3	8	4	6	10
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	1	3	3	2	5	2	4	3	3	2	4	5	5	6	6
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	3	2	3	2	4	3	4	2	3	5	5	4	7
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	3	2	2	3	4	4	3	4	6	6
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	2	2	4	3	4	3	5	6
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	3	2	3	3	5	4
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	2	3	5
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	3
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	8	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	7	4	5	2	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	6	2	3	3	4	2	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	3	1	1	2	3	4	4	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	2	0	0	1	1	4	4	3	4	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	1	2	3	5	4	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25	0	0	0	0	0	1	3	5	5	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	1	3	4	7	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	6	7	2	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	0	0	0	0	0	4	7	4	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29	0	0	0	0	4	9	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	1	7	5	5	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31	1	5	6	5	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32	4	7	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
7	7	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
11	7	6	4	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
10	6	9	8	4	3	3	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
6	8	9	8	5	5	4	3	4	2	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
8	7	7	7	9	4	5	2	5	3	3	4	2	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
7	8	8	8	6	7	4	6	2	3	4	4	3	3	4	1	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8
8	15	6	7	12	7	9	3	5	3	2	4	2	5	3	2	5	2	2	1	1	0	0	0	0	0	0	0	0	0	0	0	9
6	8	9	6	11	10	10	9	5	5	4	3	4	2	3	4	2	5	2	4	2	1	2	0	0	0	0	0	0	0	0	0	10
4	8	7	6	8	7	9	7	7	9	6	5	5	4	5	2	3	4	2	5	2	4	3	1	2	0	0	0	0	0	0	0	11
4	6	7	9	5	6	6	9	6	6	4	6	7	5	6	5	7	3	2	3	4	4	3	3	3	2	2	0	0	0	0	0	12
6	6	5	8	5	7	7	6	8	6	4	5	3	3	5	5	8	5	7	5	4	3	4	4	4	3	2	2	2	0	0	0	13
7	5	7	7	7	6	7	6	7	6	6	5	3	3	4	2	4	4	6	6	7	6	5	5	5	3	4	4	3	2	0	0	14
6	6	6	7	6	8	7	6	8	6	5	4	5	4	3	3	4	3	3	5	4	5	6	7	5	6	6	6	3	4	2	1	15
5	6	6	6	8	7	7	8	5	8	7	5	5	4	4	3	3	3	4	3	3	3	5	4	6	7	6	7	7	7	4	3	16
0	8	6	5	8	7	8	8	7	8	5	6	5	3	4	4	4	4	3	4	4	3	4	4	3	5	5	5	7	7	7	7	17
0	1	5	5	6	8	8	10	7	7	7	6	3	4	4	3	6	4	4	4	4	5	3	4	4	3	4	4	4	6	7	8	18
0	0	2	5	3	6	7	9	8	8	7	6	5	5	4	4	4	4	5	5	4	4	4	4	4	6	4	4	4	4	6	6	19
0	0	1	4	4	4	5	6	6	8	9	7	4	5	5	4	4	5	5	4	5	6	4	5	5	5	4	6	5	4	5	5	20
0	0	0	3	4	6	4	6	5	5	6	5	6	4	4	6	4	6	4	7	4	7	4	7	4	7	5	6	5	6	5	6	21
0	0	0	1	3	7	5	6	7	5	4	2	1	3	6	5	5	7	5	6	8	4	7	8	4	8	7	5	8	5	7	4	22
0	0	0	0	4	4	8	8	5	6	4	1	0	0	1	3	6	7	6	8	6	9	8	6	9	7	9	9	6	9	4	2	23
0	0	0	0	2	5	7	8	9	6	3	0	0	0	0	0	1	4	6	8	10	10	9	9	11	11	10	11	8	4	3	0	24
0	0	0	0	2	5	0	8	13	4	0	0	0	0	0	0	0	0	5	4	6	10	9	20	10	23	8	5	7	0	0	0	25
0	0	0	0	2	8	4	11	12	3	0	0	0	0	0	0	0	0	0	1	9	12	21	24	23	14	9	2	0	0	0	0	26
0	0	0	0	2	8	6	14	10	0	0	0	0	0	0	0	0	0	0	0	0	27	30	10	37	7	0	0	0	0	0	0	27
0	0	0	0	3	10	8	10	9	0	0	0	0	0	0	0	0	0	0	7	15	20	25	21	20	7	0	0	0	0	0	0	28
0	0	0	0	7	10	8	9	5	1	0	0	0	0	0	0	2	6	0	11	16	16	20	15	9	9	3	0	0	0	0	0	29
0	0	0	3	9	10	7	6	4	1	0	0	0	1	4	6	5	10	11	12	11	12	10	12	9	6	5	1	0	0	0	0	30
0	0	1	8	7	10	5	5	3	1	1	2	4	5	8	8	8	8	0	10	0	8	9	7	9	6	3	2	1	0	2	5	31
0	0	7	7	7	7	5	5	4	4	3	6	8	7	7	5	8	7	6	8	7	6	7	6	7	6	2	3	4	3	7	5	32

FIGURE 7. (c) Hough Transform of Bridge Pattern at 112.5 Degrees.



(a) Pictorial Print of Processed Input Image.

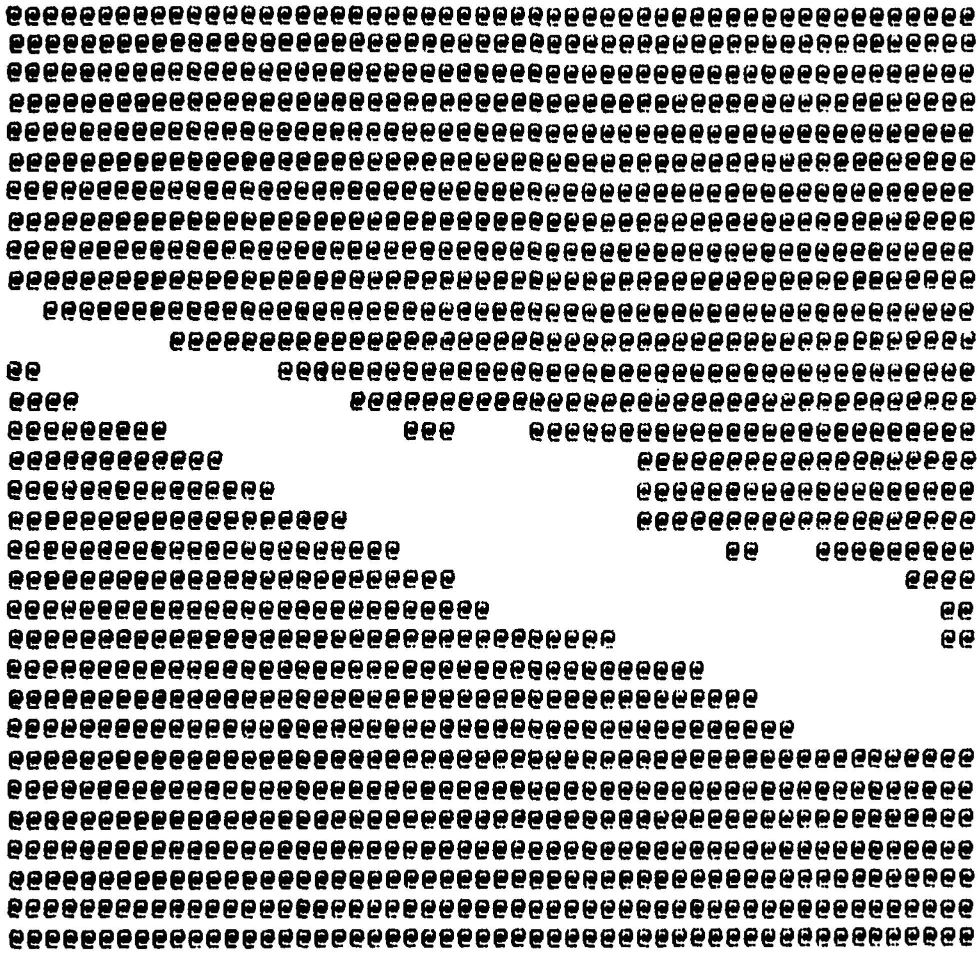
```
IROW =  14
ICOL =  15
ANS =    1
ITT -   18.
J =     26
R1 = 135.0
Bridge Detected at 135.0 Degrees with X-Axis.
```

FIGURE 8. (b) Recognition Result of Bridge Pattern at 135 Degrees.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
1	0	0	0	0	6	6	6	6	6	6	7	8	8	7	7	7	7	4	3	3	2	1	0	0	0	0	0	2	2	2	2	0
2	0	0	0	0	0	0	6	5	5	5	6	6	7	8	10	10	9	6	6	5	3	2	1	0	0	0	0	0	0	2	2	1
3	0	0	0	0	0	0	0	0	3	5	5	4	6	7	8	9	10	11	7	7	6	7	3	2	0	0	0	0	0	0	0	2
4	0	0	0	0	0	0	0	0	0	0	1	2	7	7	7	6	7	10	9	8	7	6	9	7	3	2	2	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	3	4	7	7	8	9	7	7	7	7	9	6	5	6	3	3	2	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	4	5	9	7	8	5	7	6	8	6	6	6	5	5	4	3
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	2	3	5	6	8	4	7	6	6	7	4	7	5	6	4
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2	4	3	3	5	3	5	5	8	6	5	6	5	5
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	2	5	2	2	3	2	6	2	8	5	3	7
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	4	2	4	3	2	2	1	3	4	4	5
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	4	4	2	4	1	1	3	1	4
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	3	4	3	2	3	2	1	2
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	4	4	3	3	2	1
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	5	3	3	3
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	5	3
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	6	5	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	7	6	6	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	9	10	7	7	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	9	12	10	9	7	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	9	13	12	12	9	5	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	10	9	12	13	12	8	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25	7	15	13	11	14	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0
26	8	25	13	13	10	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	11	10	14	11	13	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	12	14	15	9	8	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29	15	14	10	6	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	11	10	6	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31	8	6	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
0	2	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
0	1	1	2	1	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
0	0	0	1	1	2	0	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
1	2	0	0	0	1	1	1	1	1	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
4	5	3	3	2	0	0	0	2	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
4	5	6	3	5	4	3	2	1	1	1	1	1	0	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8
5	6	2	4	7	3	6	4	6	2	2	3	1	1	1	0	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	9
4	5	5	5	3	5	5	4	6	4	4	4	5	4	2	2	1	1	1	0	2	0	0	0	0	0	0	0	0	0	0	0	10
2	3	4	3	6	3	5	4	4	5	4	6	5	4	4	7	3	3	2	1	1	1	1	0	0	0	0	0	0	0	0	0	11
3	1	2	2	3	3	3	3	6	4	4	4	5	5	5	5	5	6	6	4	2	2	1	1	1	0	0	0	0	0	0	0	12
2	3	2	1	1	1	2	2	2	3	3	5	5	4	5	4	5	7	6	4	6	6	4	4	1	1	0	0	0	0	0	0	13
2	1	2	2	2	2	1	1	0	1	2	2	2	3	5	6	4	4	5	7	7	6	5	6	5	6	2	0	0	0	0	0	14
3	2	2	2	3	2	2	1	0	1	0	0	1	2	2	2	3	5	6	5	6	5	7	7	7	6	5	6	3	0	0	0	15
5	3	3	1	1	3	2	2	2	1	1	0	0	0	0	1	2	3	3	3	5	6	7	6	5	7	8	7	6	5	4	0	16
0	6	5	4	2	2	2	3	2	2	1	1	0	0	0	0	0	0	1	2	3	4	5	6	7	7	7	8	8	6	5	5	17
0	0	0	6	6	3	3	3	3	2	2	1	1	0	0	0	0	0	0	0	0	2	4	5	5	5	7	8	8	7	7	6	18
0	0	0	0	3	6	6	2	2	3	3	3	1	1	0	0	0	0	0	0	0	0	1	3	3	5	5	6	6	8	8	9	19
0	0	0	0	0	0	4	7	5	3	3	3	3	1	1	0	0	0	0	0	0	0	1	2	1	2	4	5	4	6	6	10	20
0	0	0	0	0	0	0	2	4	7	5	4	3	3	2	0	0	0	0	0	0	1	1	1	2	1	1	2	3	4	6	6	21
0	0	0	0	0	0	0	0	1	3	6	7	5	3	4	1	0	0	0	0	0	1	2	2	1	1	1	0	0	2	4	6	22
0	0	0	0	0	0	0	0	0	0	2	6	8	6	5	3	0	0	0	0	1	2	2	1	2	0	0	0	0	0	0	5	23
0	0	0	0	0	0	0	0	0	0	0	1	6	6	11	6	0	0	0	1	2	2	2	1	0	0	0	0	0	0	0	0	24
0	0	0	0	0	0	0	0	0	0	0	0	1	6	7	9	7	0	1	2	2	3	0	0	0	0	0	0	0	0	0	0	25
0	0	0	0	0	0	0	0	0	0	0	0	0	2	5	12	9	3	4	3	0	0	0	0	0	0	0	0	0	0	0	0	26
0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	9	17	7	2	0	0	0	0	0	0	0	0	0	0	0	1	10	27
0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	14	11	5	2	2	0	0	0	0	0	0	0	0	0	6	0	8	28
0	0	0	0	0	0	0	0	0	0	0	0	3	5	1	8	9	6	3	2	1	0	0	0	0	0	0	5	6	7	11	11	29
0	0	0	0	0	0	0	0	0	0	4	4	0	0	4	5	8	5	4	2	2	0	0	0	1	5	4	0	0	11	8	10	30
0	0	0	0	0	0	0	2	3	3	0	0	0	1	4	5	7	5	3	2	2	1	3	4	5	7	9	9	6	8	8	0	31
0	0	0	0	0	3	3	2	0	0	0	0	1	2	3	5	7	4	3	4	5	5	6	7	8	7	7	7	7	6	6	0	32

FIGURE 8. (c) Hough Transform of Bridge Pattern at 135 Degrees.



(a) Pictorial Print of Processed Input Image.

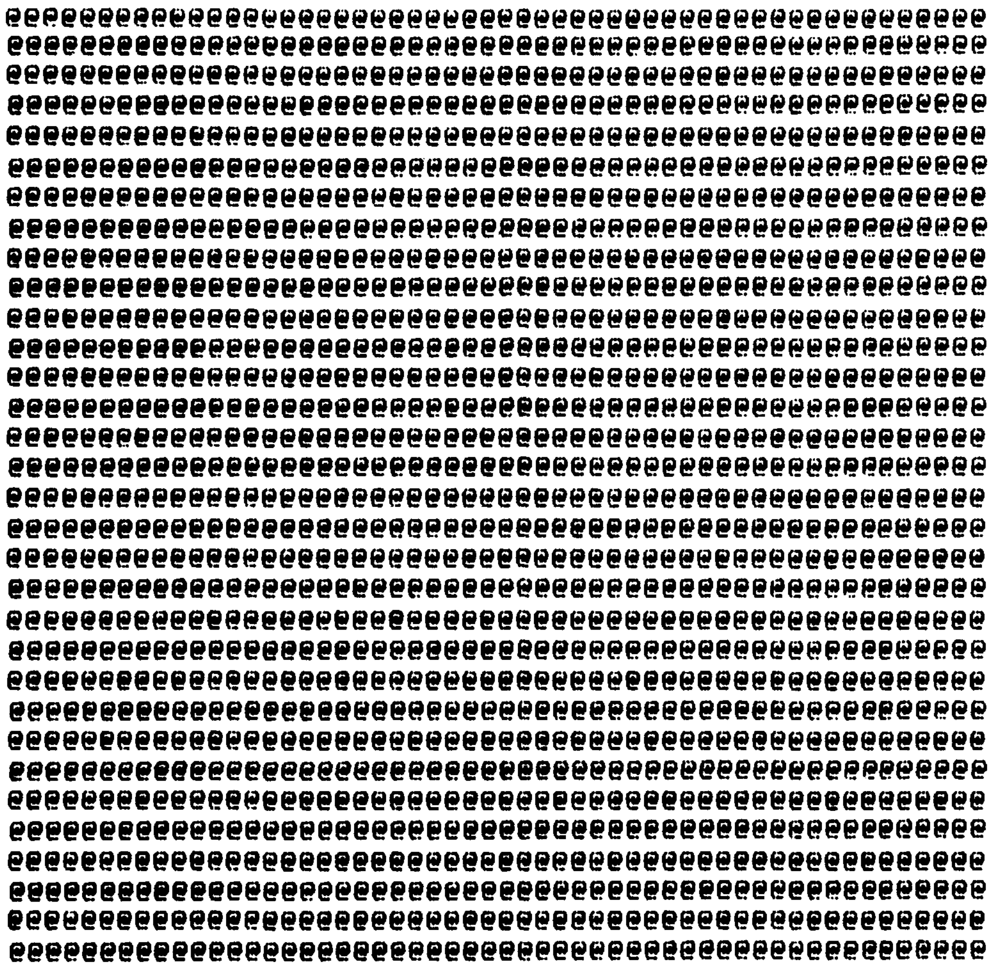
```
IROW =   29
ICOL =   14
ANS  =    1
ITT  -   14.
J =      25
R1 = 157.5
Bridge Detected at 157.5 Degrees with X-Axis.
```

FIGURE 9. (b) Recognition Result of Bridge Pattern at 157.5 Degrees.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
1	0	0	0	0	0	0	0	0	5	7	5	7	10	8	10	16	15	10	13	10	16	10	10	6	3	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	5	5	6	6	9	9	8	8	14	16	12	13	16	14	11	8	6	3	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	1	5	5	7	8	8	10	6	8	13	13	13	15	13	14	15	9	4	2	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	2	6	5	9	7	8	9	7	8	8	16	11	15	14	13	14	9	6	2	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	5	6	9	9	7	10	7	7	8	10	12	15	13	14	13	12	8
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	4	6	9	10	8	9	8	8	7	7	10	13	12	17	13
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	8	10	8	10	9	8	9	6	7	4	13	13
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	3	8	8	16	12	9	9	9	6	6	3
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	8	7	14	9	15	7	6	9
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	4	9	11	12	13	10
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	10	10	13
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	9
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
10	11	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
12	17	11	11	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
7	13	12	16	13	13	7	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8
3	6	4	6	17	10	20	9	12	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9
9	5	6	2	6	8	12	11	14	13	10	6	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10
11	14	10	5	3	4	5	8	8	12	11	15	10	6	6	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11
11	12	14	14	10	7	2	2	5	8	9	9	14	12	9	8	5	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	12
3	8	11	14	13	13	13	7	3	1	6	8	8	9	12	11	10	6	6	5	2	0	0	0	0	0	0	0	0	0	0	0	13
0	0	2	0	11	14	14	13	13	7	4	2	6	8	9	9	9	11	8	8	6	4	3	0	0	0	0	0	0	0	0	0	14
0	0	0	0	2	8	14	13	13	14	12	8	2	4	5	8	11	8	9	8	9	7	6	4	3	0	0	0	0	0	0	0	15
0	0	0	0	0	0	4	7	12	13	14	14	13	7	5	4	7	8	10	7	9	8	8	6	6	4	3	0	0	0	0	0	16
0	0	0	0	0	0	0	0	5	9	12	14	14	15	10	8	6	7	7	8	8	7	8	7	8	6	5	3	2	0	0	0	17
0	0	0	0	0	0	0	0	0	2	7	9	13	14	15	12	10	9	9	7	7	7	8	7	7	7	7	5	4	2	1	0	18
0	0	0	0	0	0	0	0	0	0	1	5	8	10	14	16	13	11	11	11	9	6	5	7	7	8	7	7	5	4	2	2	19
0	0	0	0	0	0	0	0	0	0	0	1	4	7	10	12	13	15	12	13	13	10	7	5	6	8	6	8	7	4	5	2	20
0	0	0	0	0	0	0	0	0	0	0	0	1	3	8	9	12	13	13	14	14	13	12	7	6	5	7	7	9	6	4	4	21
0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	8	11	12	12	13	15	14	14	10	8	6	7	7	7	7	6	4	22
0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	5	9	13	11	15	11	15	15	11	12	7	8	8	7	7	4	5	23
0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	8	9	13	15	13	13	13	13	11	12	9	9	9	7	4	4	24
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	9	8	19	9	9	19	10	16	8	10	9	8	9	4	8	3	25
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	7	12	14	13	13	14	13	9	11	15	15	11	5	7	6	1	26
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	11	15	11	13	12	15	13	8	14	14	15	9	7	8	1	0	27
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	11	14	12	13	14	13	12	10	16	13	12	10	9	0	0	0	28
0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	13	12	12	14	12	15	12	13	14	10	15	11	9	1	0	0	0	29
0	0	0	0	0	0	0	0	0	0	0	0	0	6	12	13	12	12	15	15	13	12	12	14	13	9	8	3	0	0	0	0	30
0	0	0	0	0	0	0	0	0	0	0	2	6	10	15	12	15	17	12	11	11	16	12	10	7	8	5	0	0	0	0	0	31
0	0	0	0	0	0	0	0	0	0	4	0	11	12	16	16	16	9	13	16	13	10	7	6	7	5	0	0	0	0	0	0	32

FIGURE 9. (c) Hough Transform of Bridge Pattern at 157.5 Degrees.



(a) Pictorial Print of Processed Input Image.

```
IROW =     0
ICOL =     0
ANS =      0
ITT -     47.
J =       25
R1 =  157.5
"not a bridge."
```

FIGURE 10. (b) Recognition Result of an Entirely Black Area.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
1	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32
2	3	13	23	32	33	32	32	33	32	32	33	32	32	32	32	32	32	32	32	32	32	32	32	32	33	32	32	33	32	32	33	32
3	0	4	9	14	19	26	33	32	32	32	32	32	32	32	32	34	36	33	32	32	12	32	32	32	32	34	35	34	32	32	32	32
4	0	0	3	0	10	15	10	21	25	20	33	33	34	33	34	33	34	33	34	33	34	32	34	33	34	33	34	33	34	33	34	33
5	0	0	0	2	5	9	10	14	17	19	23	24	20	31	33	34	35	35	35	35	34	35	34	35	35	34	35	34	34	36	34	36
6	0	0	0	0	1	3	6	9	11	12	16	10	20	22	26	27	30	33	35	35	36	37	37	35	36	30	36	36	35	30	36	36
7	0	0	0	0	0	0	1	4	7	7	11	12	14	19	16	23	24	23	31	25	35	36	32	43	32	42	43	32	43	32	42	43
8	0	0	0	0	0	0	0	0	1	5	5	0	10	11	14	16	19	19	22	25	25	29	30	32	34	36	40	39	42	41	42	41
9	0	0	0	0	0	0	0	0	0	0	1	5	4	5	13	0	19	11	12	27	15	33	10	17	41	22	47	25	53	20	29	61
10	0	0	0	0	0	0	0	0	0	0	0	0	1	2	4	7	9	10	13	15	16	20	20	23	24	29	29	30	33	36	37	30
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	5	9	11	10	16	14	21	23	19	20	23	33	35	20	40
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	4	7	10	12	14	16	19	21	24	26	29	31	34
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	5	9	11	14	17	19	24	25	20	31
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	10	15	10	21	25	20
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	11	15	20	25
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	17
17	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	32	27	16	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	32	27	24	10	11	6	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	30	27	23	20	17	12	10	5	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	29	20	23	21	19	15	13	9	7	5	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	29	27	25	21	19	17	14	11	10	0	5	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	31	22	27	20	20	19	13	15	10	9	7	4	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25	20	26	25	21	19	19	16	13	12	10	0	5	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	20	37	17	31	14	25	11	10	17	7	11	4	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	20	26	25	21	19	19	16	13	12	10	0	5	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	31	22	27	20	20	19	13	15	10	9	7	4	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29	29	27	25	21	19	17	14	11	10	0	5	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	29	20	23	21	19	15	13	9	7	5	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31	30	27	23	20	17	12	10	5	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32	32	27	24	10	11	6	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
27	17	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
30	25	20	15	11	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
33	20	25	21	10	15	10	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
33	31	20	25	24	19	17	14	11	9	5	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
35	34	31	29	26	24	21	19	16	14	12	10	7	4	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
32	40	20	35	33	23	20	19	23	21	14	16	10	11	9	5	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
42	30	37	36	33	30	29	29	24	23	20	20	16	15	13	10	9	7	4	2	1	0	0	0	0	0	0	0	0	0	0	0	8
32	61	29	20	53	25	47	22	41	19	10	33	15	27	12	11	19	0	13	5	4	5	1	0	0	0	0	0	0	0	0	0	9
42	41	42	41	42	39	40	36	34	32	30	29	25	25	22	19	19	16	14	11	10	0	5	5	1	0	0	0	0	0	0	0	10
32	43	42	32	43	32	43	42	32	43	32	36	35	25	31	23	24	23	16	19	14	12	11	7	7	4	1	0	0	0	0	0	11
35	36	36	30	35	36	36	30	36	35	37	37	36	35	35	33	30	27	26	22	20	10	16	12	11	9	6	3	1	0	0	0	12
33	36	34	36	34	34	35	34	35	35	34	35	34	35	35	35	35	34	33	31	20	24	23	19	17	14	10	9	5	2	0	0	13
33	33	34	33	34	33	34	33	34	33	34	32	34	33	34	33	34	33	34	33	34	33	33	20	25	21	10	15	10	0	3	0	14
30	32	32	32	32	34	35	34	32	32	32	32	32	32	32	33	36	34	32	32	32	32	32	32	32	32	33	26	19	14	9	4	15
27	32	33	32	32	33	32	32	33	32	32	32	32	32	32	32	32	32	32	32	32	32	33	32	32	33	32	32	33	32	23	13	16
0	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	17
0	5	15	25	32	32	32	32	32	32	32	32	32	33	32	32	33	32	32	33	32	32	32	32	32	32	32	32	32	32	32	32	18
0	2	7	12	19	25	20	32	32	32	32	32	32	32	35	35	32	32	32	32	32	32	32	32	35	35	32	32	32	32	32	32	19
0	1	6	0	12	16	19	23	26	31	33	33	33	34	33	34	33	34	33	34	33	34	33	34	33	34	33	34	33	34	33	34	20
0	1	4	6	10	12	15	10	20	24	27	29	33	34	34	35	35	35	34	34	35	35	34	36	34	35	34	34	36	34	35	32	21
0	1	3	5	0	11	13	15	10	20	22	24	20	30	32	35	36	36	36	37	36	36	36	37	36	36	36	37	36	36	34	30	22
0	1	3	4	0	0	13	15	13	20	17	25	27	22	32	26	37	39	31	43	32	43	42	32	43	33	42	42	31	39	29	32	23
0	1	2	5	7	9	10	13	15	17	19	21	23	25	27	29	31	33	36	37	40	41	41	41	42	42	39	39	36	34	33	29	24
0	1	2	3	9	6	15	9	21	12	13	29	16	35	19	20	43	23	49	26	27	57	30	63	31	59	20	27	51	24	45	21	25
0	1	2	5	7	9	10	13	15	17	19	21	23	25	27	29	31	33	36	37	40	41	41	41	42	42	39	39	36	34	33	29	26
0	1	3	4	0	0	13	15	13	20	17	25	27	22	32	26	37	39	31	43	32	43	42	32	43	33	42	42	31	39	29	32	27
0	1	3	5	0	11	13	15	10	20	22	24	20	30	32	35	36	36	36	37	36	36	36	37	36	36	36	37	36	36	34	30	28
0	1	4	6	10	12	15	10	20	24	27	29	33	34	34	35	35	35	34	34	35	35	34	36	34	35	34	34	36	34	35	32	29
0	1	6	0	12	16	19	23	26	31	33	33	33	34	33	34	33	34	33	34	33	34	33	34	33	34	33	34	33	34	33	34	30
0	2	7	12	19	25	20	32	32	32	32	32	32	32	35	35	32	32	32	32	32	32	32	32	35	35	32	32	32	32	32	32	31
0	5	15	25	32	32	32	32	32	32	32	32	32	33	32	32	33	32	32	33	32	32	32	32	32	32	32	32	32	32	32	32	32

FIGURE 10. (c) Hough Transform of an Entirely Black Area.

BRIDGE DETECTED AT 162.00 DEGREES WITH X AXIS

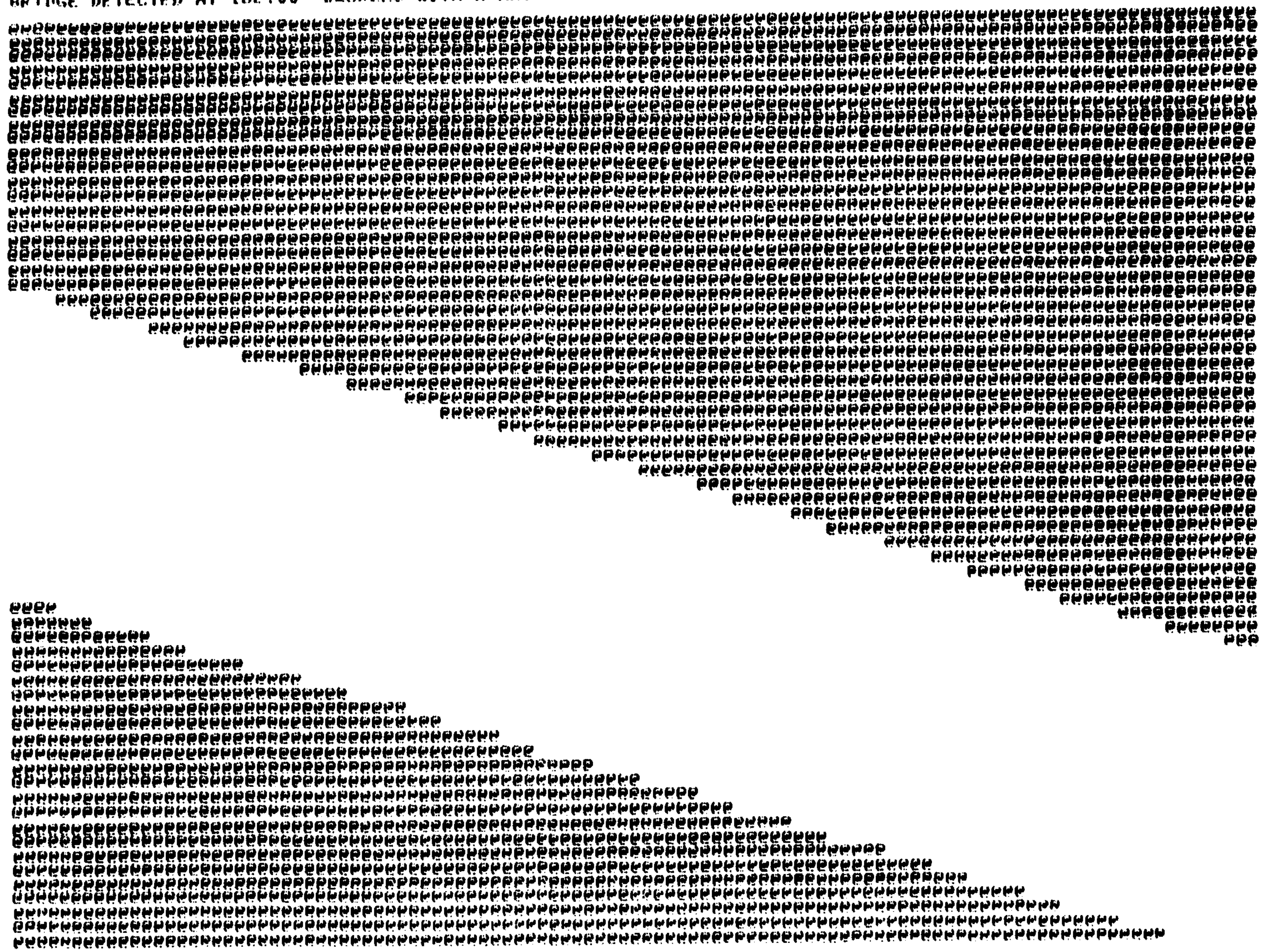


FIGURE 11. Pictorial Print of Processed Input Image, and Recognition Result of Bridge Pattern at 162 Degrees with Large Measurement Window.

BRIDGE DETECTED AT 172.00 DEGREES WITH X AXIS

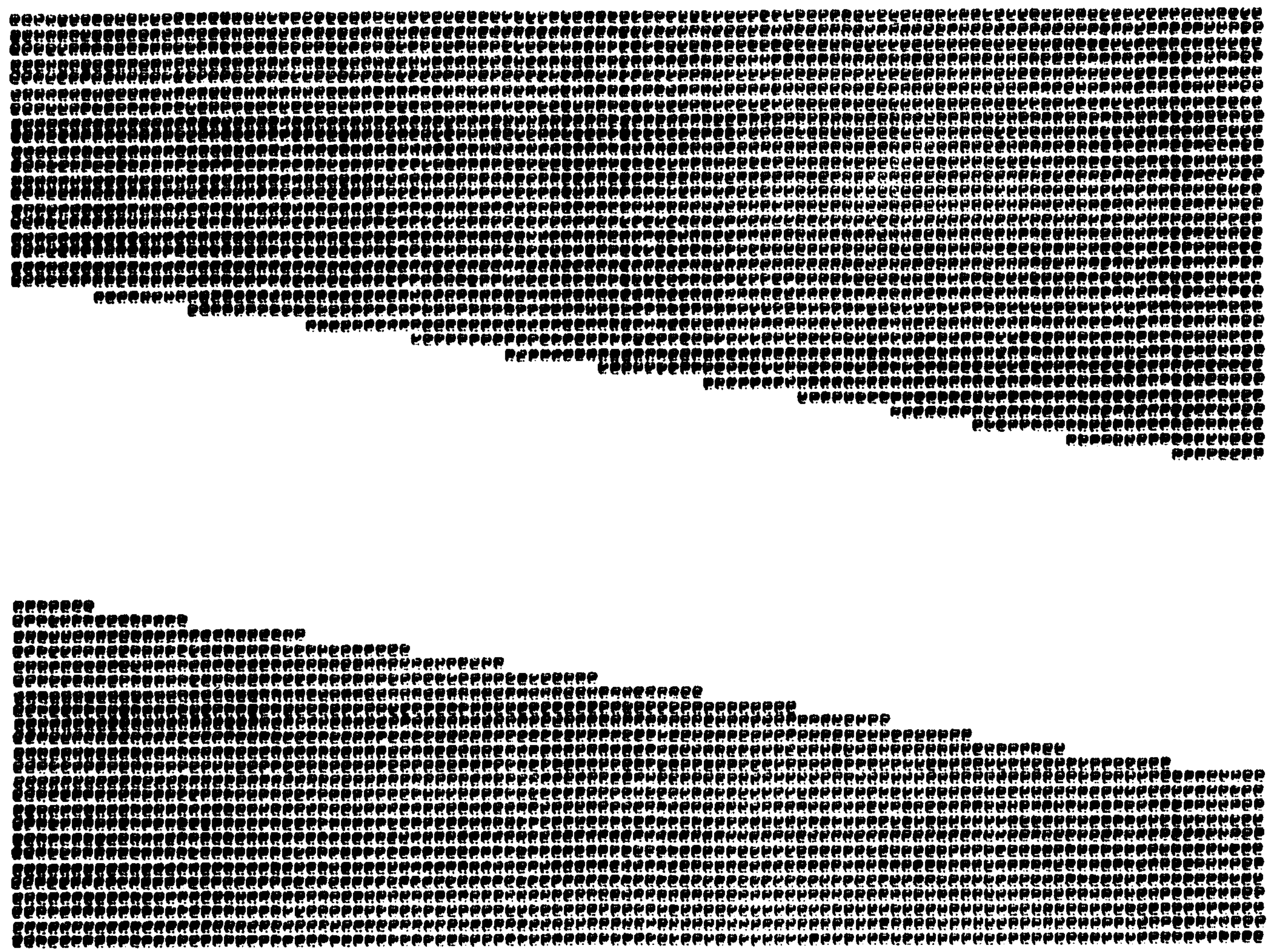


FIGURE 12. Pictorial Print of Processed Input Image, and Recognition Result of Bridge Pattern at 172 Degrees with Large Measurement Window.

APPENDIX
SOFTWARE LISTING

```
&RDS   T=00004 IS ON CR00009 USING 00071 BLKS R=0000

FTN4,L
C*****************PROGRAM "RDS"-----REV 05/14/82*********************
C     THIS PROGRAM RECOGNIZES A BRIDGE OVER WATER USING THE HOUGH
C     TRANSFORM WHICH CONVERTS A LINE INTO A POINT. THE EDGES ARE
C     DETECTED USING A SOBEL OPERATION (SUBROUTINE "SOBEL").
C      MODIFIED TO RUN IN THE RTE OP. SYS.
C
C
C
C
       PROGRAM RDS
       COMMON IXPOS,IYPOS,IRUN,IMAGE,IA1
       COMMON LEXLU
       DIMENSION IA3(1026)
       EQUIVALENCE(IA1,IA3(3))
       DIMENSION IA1(1024),IA2(1024)
       DIMENSION IEDGE(1024),IDCB(144),IXBUF(49),IYBUF(49)
       DIMENSION IXFRM(64,32),IA(64,32),MAX(11),IMAX(11)
       DIMENSION JMAX(11)
       DIMENSION IDARK(512),INPUT(43),LABIN(10),LABPT(10),LABEG(10)
       DIMENSION NAME(3),LABHU(10),LABA(10)
       DIMENSION IWRD(7),IWR2(7)
       DATA INPUT/2HIS,2HIN,2HPS,2HPI,2HJP,2HTR,2HSR,2HII,2HFV,2HIH,2HFD,
      12HOR,2HLU,2HXY,2HRS,2HNI,2HDK,2HNA,2HIM,2HRU,2HRA,2HRI,2HGR,2HPA,
      22HGL,2HMA,2HMN,2HTF,2HST,2HHG,2HHS,2HAP,2HSP,2HOE,2HPE,2HHU,2HPH,
      32HTT,2HBD,2HTS,2HLX,2HFA,2HFA/
       DATA LABIN/2HIN,2HPU,2HT ,7*2H  /
       DATA LABPT/2HIN,2HPU,2HT ,2HSC,2HAL,2HED,4*2H  /
       DATA IYES/2HYE/
       DATA LABEG/2HED,2HGE,8*2H  /
C
C      SET VARIABLES TO DEFAULT VALUES
C
       IC=0
       CALL RMPAR(IA1)
       IF (IA1.EQ.0)IA1=1
       LU=IA1
       LUOT=LU
       CALL LUNT(75B,LUWAT,I)
       IT1=0
  3    WRITE(LU,2)
  2    FORMAT("STEP FILE NAME?")
       READ(LU,30)NAME
  4    CALL OPEN(IDCB,I,NAME)
       CALL FEROR(I,4,LU)
       IF (I.LT.0)GO TO 3
       CALL READF(IDCB,IERR,IXBUF,49,IMAGS)
       CALL READF(IDCB,IERR,IYBUF,49,IMAGS)
       CALL CLOSE(IDCB)
       IMAGS=IMAGS+1
       WRITE(LU,1)IMAGS
  1    FORMAT("NO. OF IMAGES=",I2)
       NAV=5
       IXPOS=0
       IYPOS=0
       IMAGE=1
       IRUN=0
       NGRAY=16
```

```
      ITH=0
      ISS=1
      IDIR=1
      IOR=2
      III=0
      MAX=0
      MIN=0
      NCHRS=72
      IDIM=32
      IA3(1)=MAX
      IA3(2)=MIN
      IB=-1
C
C     INPUT COMMAND LOOP
C
C       DK--INPUT ARRAY DARK LEVELS
C       LU--INPUT LIST LU
C       IN--INPUT ARRAY DATA
C       IT--INPUT THRESHOLD CONSTANT FOR INPUT IMAGE
C       PI--PRINT THE INPUT ARRAY
C       TR--TERMINATE PROGRAM
C       TH--THRESHOLD FOR BACKGROUND
C       SB--SOBEL OPERATION
C       OE--OUTPUT RESULT OF SOBEL OPERATION
C       HU--HOUGH TRANSFORM
C       PH--OUTPUT HOUGH TRANSFORM MATRIX
C       TT--THRESHOLD VALUE FOR DETECTING AN EDGE
C       BD--BRIDGE DETECTION
C       TS--INPUT THRESHOLD VALUE BEFORE SOBEL OPERATION
C       LX--DISPLAY RESULT OF BRIDGE DETECTION ROUTINE ON LEXIDATA
C       PE--DISPLAY HARD COPY OF INPUT IMAGE
C       XY--SLEW TO AN IMAGE
C       IS--INPUT STAGE STEPS FOR NEXT IMAGE
C       OR--INPUT ORIENTATION VALUE
C       RS--RESET TO FIRST IMAGE
C       NI--SLEW TO NEXT IMAGE IN SEQUENCE
C       NA--INPUT NUMBER OF FRAMES AVERAGED
C       IM--SLEW TO SELECTED IMAGE
C       RU--AUTOMATIC RUN THROUGH IMAGES
C       RA--RUN AGAIN STARTING AT STATEMENT 3
C       RI--REMOVE SELECTED IMAGE
C
   10 WRITE(LU,20)
   20 FORMAT("??")
      READ(LU,30)ICMND
   30 FORMAT(3A2)
      IF (ICMND.EQ.INPUT(1))GO TO 100
      IF (ICMND.EQ.INPUT(2))GO TO 200
      IF (ICMND.EQ.INPUT(8))READ(LU,*)III
      IF (ICMND.EQ.INPUT(4))GO TO 300
      IF (ICMND.EQ.INPUT(10))READ(LU,*)ITH
      IF (ICMND.EQ.INPUT(11))GO TO 6000
      IF (ICMND.EQ.INPUT(20))GO TO 1300
      IF (ICMND.EQ.INPUT(15))CALL RESET
      IF (ICMND.EQ.INPUT(16))GO TO 1000
      IF (ICMND.EQ.INPUT(18))READ(LU,*)NAV
      IF (ICMND.EQ.INPUT(19))GO TO 1200
      IF (ICMND.EQ.INPUT(21))GO TO 2100
      IF (ICMND.EQ.INPUT(22))GO TO 2300
      IF (ICMND.EQ.INPUT(17))GO TO 1100
```

```
      IF (ICMND.EQ.INPUT(13))GO TO 500
      IF (ICMND.EQ.INPUT(6))GO TO 1400
      IF (ICMND.EQ.INPUT(33)) GOTO 4000
      IF (ICMND.EQ.INPUT(35)) GOTO 4200
      IF (ICMND.EQ.INPUT(37)) GOTO 4600
      IF (ICMND.EQ.INPUT(34)) GOTO 4100
      IF (ICMND.EQ.INPUT(36)) GOTO 4500
      IF (ICMND.EQ.INPUT(38))READ(LU,*)ITT
      IF (ICMND.EQ.INPUT(14))GOTO 600
      IF (ICMND.EQ.INPUT(40))READ(LU,*)IT2
      IF (ICMND.EQ.INPUT(41)) GOTO 987
      IF (ICMND.EQ.INPUT(24)) GO TO 6800
 31   FORMAT("1")
      GO TO 10
C
C     STORE STAGE STEPS FOR NEXT IMAGE OR INSERTED IMAGE
C
C      SLEW TO STARTING IMAGE, 0 INPUT ABORTS
C      SECTION.
C
C
 100  WRITE(LU,101)
 101  FORMAT("START AT IMAGE #?")
      READ(LU,*)I
      IF(I.GT.IMAGS.OR.I.LT.1)GO TO 10
      IRUN=2
      CALL STEPS(IXBUF,IYBUF,IMAGE,I,IXSTP,IYSTP)
      IXPOS=IXPOS+IXSTP
      IYPOS=IYPOS+IYSTP
      IMAGE=I
      CALL SSLEW(-IXSTP,-IYSTP,1)
C
C     INPUT ADD OR INSERTIMAGE FLAG, "ICMND", AND MOVE TO
C     NEW IMAGE WITH KBRD CONTROL.
C
      WRITE(LU,120)
 120  FORMAT("ADD(1) OR INSERT(2) IMAGES?")
      READ(LU,*)ICMND
 107  WRITE(LU,102)
 102  FORMAT("MOVE STAGES WITH KBRD UNTIL DESIRED IMAGE IS")
      WRITE(LU,103)
 103  FORMAT("DISPLAYED. ENTER 1 TO STORE NEW IMAGE POSITION")
      WRITE(LU,109)
 109  FORMAT("ENTER 2 FOR FEATURE DETECTION")
      IXD=0
      IYD=0
 105  READ(LU,*)IXSTP,IYSTP
      IF(IXSTP.EQ.1)GO TO 104
      IF(IXSTP.EQ.2)GO TO 200
      CALL SSLEW(-IXSTP,-IYSTP,1)
      IXD=IXD+IXSTP
      IYD=IYD+IYSTP
      GO TO 105
C
C     COMPUTE NEW STAGE POSITIONS RELATIVE TO STARTING
C     IMAGE AND BRANCH TO ADD INSERT SECTION.
C
 104  IXPOS=IXPOS+IXD
      IYPOS=IYPOS+IYD
      IF(ICMND.EQ.2)GO TO 111
```

```
C
C     ADD IMAGE SECTION: STORE NEXT IMAGE STEPS
C
      IXBUF(IMAGE)=IXD
      IYBUF(IMAGE)=IYD
      GO TO 114
C
C     INSERT IMAGE SECTION: INSERT NEW STEPS INTO CURRENT
C     IMAGE INDEX, MOVE IXBUF AND IYBUF DOWN, COMPUTE STEPS
C     FROM NEW IMAGE TO OLD NEXT IMAGE AND STORE IN INDEX+1
C
111   IXSTP=IXBUF(IMAGE)-IXD
      IYSTP=IYBUF(IMAGE)-IYD
      IXBUF(IMAGE)=IXD
      IYBUF(IMAGE)=IYD
      IF(IMAGS-IMAGE.LT.2)GO TO 115
      DO 113 I=1,IMAGS-IMAGE-1
      IXBUF(IMAGS-I+1)=IXBUF(IMAGS-I)
113   IYBUF(IMAGS-I+1)=IYBUF(IMAGS-I)
115   IXBUF(IMAGE+1)=IXSTP
      IYBUF(IMAGE+1)=IYSTP
      IMAGS=IMAGS+1
C
C     ASK IF TO CONTINUE AND IF NOT STORE STEP FILE
C     IN DESIGNATED NAME
C
114   IMAGE=IMAGE+1
      IF(IMAGE.EQ.50.OR.IMAGS.EQ.50)GO TO 108
      WRITE(LU,106)
106   FORMAT("CONTINUE?")
      READ(LU,30)I
      IF(I.EQ.IYES)GO TO 107
108   IF(ICMND.EQ.1)IMAGS=IMAGE
112   WRITE(LU,2)
      READ(LU,30)NAME
      CALL OPEN(IDCB,I,NAME)
      IF(I.EQ.-6)CALL CREAT(IDCB,I,NAME,1,3,0,9)
      CALL WRITF(IDCB,I,IXBUF,IMAGS-1)
      CALL WRITF(IDCB,I,IYBUF,IMAGS-1)
      CALL CLOSE(IDCB)
      CALL RESET
      GO TO 10
C
C     INPUT AND AVERAGE ARRAY FRAMES, SUBTRACT DARK
C     LEVELS, THRESHOLD AND ORIENT
C
200   CALL AVGIN(IA1,IA2,1024,NAV,IDARK)
C
C     THE FOLLOWING STATEMENTS FIX AN APPARENT HARDWARE ERROR BY SORTING
C     SUCH THAT THE FIRST ROW IN "IA1" BECOMES THE LAST ROW.
C
      DO 203 I=1,1024
203   IA2(I)=IA1(I)
      DO 201 I=1,992
201   IA1(I)=IA1(I+32)
      DO 202 I=993,1024
202   IA1(I)=IA2(I-992)
      CALL IORNT(IA1,32,IOR)
C     SET THRESHOLD FOR INPUT ARRAY
C
```

```
        CALL MATR1(IA1,ITH)
        DO 220 I=1,1024
        IF(IA1(I).GE.ITH)IA1(I)=1
  220   CONTINUE
        IF(IRUN.GT.0)4000,10
C
C       PRINT INPUT IMAGE
C
  300   CALL PDATE(LUOT)
        CALL MTOUT(IA1,LABIN,32,32,3,LUOT,-NCHRS)
        GO TO 10
C
C       CHANGE PARAMETERS
C
C       INPUT LIST LU
C
  500   READ(LU,*)LUOT
        IF (LUOT.EQ.6)NCHRS=132
        IF (LUOT.EQ.LU)NCHRS=72
        GO TO 10
C
C       INPUT AND PACK DARK LEVELS
C
 1100   CALL AVGIN(IA1,IA2,1024,NAV)
        GOTO 10
C
 1400   STOP
C
C       SLEW TO NEXT IMAGE
C
 1000   IF(IFBRK(I).LT.0)GO TO 1010
        IF(IMAGE.EQ.IMAGS)GO TO 1010
        CALL SSLEW(-IXBUF(IMAGE),-IYBUF(IMAGE),1)
        IXPOS=IXPOS+IXBUF(IMAGE)
        IYPOS=IYPOS+IYBUF(IMAGE)
        IMAGE=IMAGE+1
        IF(IRUN.EQ.1)200,10
 1010   CALL RESET
        GO TO 10
C
C       SLEW TO SELECTED IMAGE
C
 1200   READ(LU,*)I
        IF(I.GT.IMAGS.OR.I.LT.1)GO TO 10
        CALL STEPS(IXBUF,IYBUF,IMAGE,I,IXSTP,IYSTP)
        IXPOS=IXPOS+IXSTP
        IYPOS=IYPOS+IYSTP
        IMAGE=I
        CALL SSLEW(-IXSTP,-IYSTP,1)
        GO TO 10
C
 1300   CALL RESET
        IRUN=1
        GO TO 200
C
C
 2300   WRITE(LU,2310)
 2310   FORMAT("IMAGE # TO BE REMOVED?")
        READ(LU,*)I
        IF(I.GT.IMAGS.OR.I.LT.1)GO TO 10
```

```
      IF(I.EQ.IMAGS)GO TO 2320
      CALL STEPS(IXBUF,IYBUF,I-1,I+1,IXD,IYD)
      IXBUF(I-1)=IXD
      IYBUF(I-1)=IYD
      DO 2330 IXD=1,IMAGS-2
      IXBUF(IXD)=IXBUF(IXD+1)
2330  IYBUF(IXD)=IYBUF(IXD+1)
2320  IMAGS=IMAGS-1
      WRITE(LU,2)
      READ(LU,30)NAME
2350  CALL OPEN(IDCB,IXD,NAME)
      IF(IXD.EQ.-6)CALL CREAT(IDCB,IXD,NAME,1,3,0,9)
      CALL WRITF(IDCB,IXD,IXBUF,I)
      CALL WRITF(IDCB,IXD,IYBYF,I)
      CALL CLOSE(IDCB)
      GO TO 10
C     SOBEL OPERATION : USED TO DETECT EDGES
C
4000  CALL SOBEL(IA1,IEDGE,32,32)
C
C     SET THRESHOLD FOR SOBEL ARRAY "IEDGE"
C
      CALL MATR2(IEDGE,IT2)
      IDIN=32
      IF(IRUN.GT.0)4500,10
C
C     OUTPUT RESULT OF SOBEL OPERATION TO LINE PRINTER
C
4100  CALL MTOUT(IEDGE,LABEG,IDIN,IDIN,3,LUOT,NCHRS)
      GOTO 10
C
C     PICTORIALLY PRINT OUTPUT OF INPUT ARRAY
C
 4200 CALL LPIM(IA1,32)
      GOTO 10
C
C     HOUGH TRANSFORM : USED TO CONVERT LINE INTO POINT
C
4500  I=1
4501  CALL HOUGH(IEDGE,32,32,IT2,IXFRM,64,32)
C
      IF(IRUN.GT.0)6000,10
C
C     PRINT HOUGH TRANSFORM MATRIX ON LINE PRINTER
C
4600  CALL MTOUT(IXFRM,LABHU,64,32,3,LUOT,-NCHRS)
      GOTO 10
C
C     SLEW TO AN IMAGE
C
600   READ(LU,*)IXSTP,IYSTP
      IF(IXSTP.EQ.1)GO TO 10
      CALL SSLEW(-IXSTP,-IYSTP,1)
      GOTO 600
 987  IC=IC+1
      IB=IB+1
C
C     DISPLAY THE INPUT ARRAY "IA1" ON THE LEXIDATA. THE SUBROUTINE IS
C     CAPABLE OF DISPLAYING 12 ARRAYS,(4 COLUMNS,3 ROWS). IT DISPLAYS
C     THEM SEQUENTIALLY STARTING AT TOP LEFT CORNER AND ENDING AT THE
```

```
C       BOTTOM RIGHT CORNER. THE WORD "BRIDGE" APPEARS IF A BRIDGE OVER
C       WATER IS DETECTED. ALSO, THE ANGLE THE BRIDGE MAKES WITH THE POS-
C       ATIVE X-AXIS IS SHOWN ON THE LEXIDATA.
C
        IF(ANS.EQ.0)GOTO 10
        IDEG=R1
        CALL LXRD(IA1,IDEG,IC,IB,ANS)
        GO TO 10
C
C       CLASSIFICATION OF BRIDGES
C
 6000   CALL BRDGE(IA1,ANS,ICOL,IROW)
        WRITE(LUOT,225)IROW
  225   FORMAT(1X,"IROW= ",I3)
        WRITE(LUOT,226)ICOL
  226   FORMAT(1X,"ICOL= ",I3)
        WRITE(LUOT,227)ANS
  227   FORMAT(1X,"ANS= ",I4)
C       SET THRESHOLD FOR HOUGH TRANSFORM ARRAY "IXFRM"
        CALL MATR3(IXFRM,ITT)
        WRITE(LUOT,4505)ITT
 4505   FORMAT(1X,"ITT= ",F3.1)
        DO 6050 J=1,32
        DO 6050 I=1,64
        IA(I,J)=IXFRM(I,J)
 6050   CONTINUE
        DO 6700 K=1,10
        MX=0
        IMX=0
        JMX=0
        DO 6600 J=1,32
        DO 6600 I=1,64
        IF(IA(I,J).LT.MX)GO TO 6600
        MX=IA(I,J)
        IMX=I
        JMX=J
 6600   CONTINUE
        MAX(K)=MX
        IMAX(K)=IMX
        JMAX(K)=JMX
        IA(IMX,JMX)=0
 6700   CONTINUE
 6900   M=0
        DO 6910 K=1,10
        IF(JMAX(K).NE.JMAX(1))GO TO 6910
        IF(MAX(K).LE.ITT)GO TO 6910
        M=M+1
        IF(M.LT.2)GO TO 6910
        J=JMAX(1)
        GO TO 6100
 6910   CONTINUE
        DO 6925 I=2,10
        M=0
        DO 6920 K=2,10
        IF(JMAX(K).NE.JMAX(I))GO TO 6920
        IF(MAX(K).LE.ITT)GO TO 6920
        M=M+1
        IF(M.LT.2)GO TO 6920
        J=JMAX(I)
        GO TO 6100
```

```
6920  CONTINUE
6925  CONTINUE
      J=JMAX(1)
      GO TO 6100
C
6800  CALL MIOUT(IA,LABA,64,32,3,LUOT,-NCHRB)
6100  WRITE(LUOT,6150)J
6150  FORMAT(1X,"J= ",I3)
      R1=(32-J)*22.5
      IF(J.LT.20)R1=180-J*2.5
      WRITE(LUOT,6160)R1
6160  FORMAT(1X,"R1= ",F5.1)
      IF(ANS.EQ.1.0)WRITE(LUOT,6170)R1
      IF(ANS.EQ.0.0)WRITE(LUOT,6180)
6170  FORMAT(1X,"BRIDGE DETECTED AT ",F5.1," DEGREES WITH X-AXIS")
6180  FORMAT(1X,"THIS IS NOT A BRIDGE")
      IF(IRUN.EQ.1)GO TO 6190
      IF(IRUN.EQ.2)105,10
6190  CALL EXEC(1,LUWAT,150,1)
      GO TO 1000
C     RESET THE MAIN PROGRAM AND INITIAL VALUES
C
2100  CALL RESET
      GO TO 3
      END
C
C    THIS IS A SUBROUTINE TO RESET THE MAIN PROGRAM "RD" TO ITS
C    INITIAL STAGES
C
      SUBROUTINE RESET
      COMMON IXPOS,IYPOS,IRUN,IMAGE
      IMAGE=1
      IRUN=0
      CALL SSLEW(IXPOS,IYPOS,1)
      IXPOS=0
      IYPOS=0
      RETURN
      END
C
C     SUBROUTINE TO CALCULATE THE NUMBER OF STEPS BETWEEN
C     IMAGES IM1 AND IM2 FROM THE SUCCESIVE DISTANCES
C     STORED IN "IXBUF" AND "IYBUF".
C
      SUBROUTINE STEPS(IXBUF,IYBUF,IM1,IM2,IXSTP,IYSTP)
      DIMENSION IXBUF(1),IYBUF(1)
      IXSTP=0
      IYSTP=0
      IF(IM1.EQ.IM2)RETURN
      M=IM1
      N=IM2
      IF(IM1.LT.IM2)GO TO 20
      M=IM2
      N=IM1
20    DO 30 I=M,N-1
      IXSTP=IXBUF(I)+IXSTP
30    IYSTP=IYBUF(I)+IYSTP
      IF(IM1.LT.IM2)RETURN
      IXSTP=-IXSTP
      IYSTP=-IYSTP
      RETURN
```

```
      END
C
C     AUTOMATIC THRESHOLD FOR INPUT IMAGE. THE ARRAY IS CALLED "IA1".
C
      SUBROUTINE MATR1(IA1,ITH)
      DIMENSION IA1(1024)
      SUM=0.
      IMAX=IA1(1)
      DO 28 I=2,1024
      IF(IA1(I).GT.IMAX1)IMAX1=IA1(I)
   28 CONTINUE
      ITH=.50*FLOAT(IMAX1)
      DO 38 I=1,1024
      IF(ITH.GT.IA1(I)) IA1(I)=0
   38 CONTINUE
      RETURN
      END
C
C     SET THRESHOLD FOR SOBEL OPERATION. USES ARRAY "IEDGE".
C
      SUBROUTINE MATR2(IEDGE,IT2)
      DIMENSION IEDGE(1024)
      SUM=0.
      IMAX=IEDGE(1)
      DO 28 I=2,1024
      IF(IEDGE(I).GT.IMAX)IMAX=IEDGE(I)
   28 CONTINUE
      IT2=FLOAT(IMAX)*.55
      DO 38 I=1,1024
      IF(IT2.GT.IEDGE(I))IEDGE(I)=0
   38 CONTINUE
      RETURN
      END
C
C     SETS THRESHOLD FOR THE HOUGH TRANSFORM. ARRAY NAME:"IXFRM".
C
      SUBROUTINE MATR3(IXFRM,ITT)
      DIMENSION IXFRM(64,32)
      IMAX=IXFRM(1,1)
      DO 28 I=1,64
      DO 28 J=1,32
      IF(IXFRM(I,J).GT.IMAX)IMAX=IXFRM(I,J)
   28 CONTINUE
      ITT=IMAX*.75
      RETURN
      END
      SUBROUTINE LXRD(IA1,IDEG,IC,IB,ANS)
**************************************************************************
******THIS DISPLAYS A 32X32 ARRAY AND THE RESULT OF A BRIDGE DETECTION
******ROUTINE*************************************************************
**************************************************************************
      COMMON LEXLU
      DIMENSION IA1(1024),INUM(2),IWD(3)
      DATA IWD/2HBR,2HID,2HGE/
      IONES=MOD(IDEG,10)
      IDEG=(IDEG-IONES)/10
      ITENS=MOD(IDEG,10)
      IDEG=(IDEG-ITENS)/10
      IHUN=MOD(IDEG,10)
      INUM(1)=256*(IHUN+48)+(ITENS+48)
```

```
      INUM(2)=256*(IONES+48)
      IR=IC-1
      IL=0
      IR=IC-1
      IF(IC.GT.4)IL=1
      IF(IC.GT.8)IL=2
      IF(IR.EQ.4)IR=0
      IF(IR.EQ.5)IR=1
      IF(IR.EQ.6)IR=2
      IF(IR.EQ.7)IR=3
      IF(IR.EQ.8)IR=0
      IF(IR.EQ.9)IR=1
      IF(IR.EQ.10)IR=2
      IF(IR.EQ.11)IR=3
      IF(IR.EQ.12)IC=0
      IF(IR.EQ.12)IL=0
      IF(IR.EQ.12)IR=0
      IF(IC.NE.1) GOTO 10
      IF(IR.NE.0) GOTO 10
      IF(ANS.EQ.0.0) GOTO 25
C
C     INITIALIZE THE LEXIDATA
C
      CALL LINIT
      CALL DSMRG(0,0,539,639,0)
      CALL DSCHN(-1,-1,-1)
C
C     JUMP TO 10 IF INITIALIZATION HAS BEEN ALREADY COMPLETED
C
 10   CALL DSLIM(38+60*IR,8+IL*70,69+60*IR,39+IL*70)
      CALL DSPUT(IA1,1024)
      CALL DSZOM(1,1,2)
      CALL DSSAO(31+60*IR,45+IL*70,1000B,0,1)
      CALL DSTXT(6,IWD)
      CALL DSSAO(40+60*IR,56+IL*70,1000B,0,1)
      CALL DSTXT(3,INUM)
 25   CONTINUE
      RETURN
      END
C
C     THIS SUBROUTINE DISTINGUISHES BETWEEN A BRIDGE OVER WATER AND
C     ANY OTHER TYPE OF GEOGRAPHY. IF A BRIDGE IS DETECTED, ANS=1 IF
C     IT IS NOT, ANS=0.
C
      SUBROUTINE BRDGE(IA1,ANS,ICOL,IROW)
      DIMENSION TX(32,32),IA1(32,32)
      N=0
      ANS=0
      N1=0
      ICOL=0
      IROW=0
      DO 10 I=1,32
      DO 10 J=1,32
      TX(I,J)=IA1(I,J)
 10   CONTINUE
      DO 20 J=1,32
      TX(1,J)=5
      TX(32,J)=5
      TX(J,1)=5
      TX(J,32)=5
```

```
20    CONTINUE
      DO 40 J=2,31
      DO 30 I=2,31
      IF(IX(I,J)+IX(I-1,J).EQ.2)N=N+1
      IF(IX(J,I)+IX(J,I-1).EQ.2)N1=N1+1
30    CONTINUE
      IF(N.LT.18.AND.N.GE.2)ICOL=ICOL+1
      IF(N1.LT.18.AND.N1.GE.2)IROW=IROW+1
      N=0
      N1=0
40    CONTINUE
      IF(ICOL.GE.8)ANS=1
      IF(IROW.GE.8)ANS=1
      RETURN
      END
      END$
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